# NEW DEVELOPMENTS IN PATHWAYS TOWARDS DIVERSITY AND INCLUSION IN STEM: A UNITED STATES PERSPECTIVE

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# NEW DEVELOPMENTS IN PATHWAYS TOWARDS DIVERSITY AND INCLUSION IN STEM: A UNITED STATES PERSPECTIVE

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# Editorial: New developments in pathways toward diversity and inclusion in STEM: A United States perspective

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Editorial on the Research Topic
New developments in pathways toward diversity and inclusion in STEM: A United States perspective

## Introduction

This volume was assembled to honor the Louis Stokes Alliances for Minority Participation (LSAMP) program of the US National Science Foundation on its 30th anniversary. LSAMP has been markedly increasing the success and graduation of underrepresented minority students in STEM for 30 years, establishing new and effective practices for diversity, equity and inclusion (Clewell et al., 2005, 2006; Hicks, 2007). LSAMP began in 1991 as the Alliances for Minority Participation (AMP) as a much smaller program [National Science Foundation (NSF), 2018a] with the goal of increasing the success and graduation of African-Americans, Hispanic and Latino Americans, Native Americans, Alaska Natives, Native Hawaiians, and Native Pacific Islanders with Bachelor's degrees in STEM disciplines.

The program grew over the years adding the name Louis Stokes in 1999 in honor of the US Congressman who championed diversity, education and the AMP program. As the program grew, the Bridges to the Doctorate activity was added in 2003, to increase the success and graduation of LSAMP students from graduate programs. The Bridges to the Baccalaureate project was added in 2013. The main goal of this project is to increase the transfer success of underrepresented minority students from community college to 4-year STEM degree programs and graduation with a STEM bachelor's degree. The Centers of Excellence (later Regional Centers of Excellence) project was also added in 2011 [National Science Foundation (NSF), 2018b]. The main goal of these centers is to increase production and dissemination of scholarly broadening participation research.

There are currently 57 LSAMP alliances composed of more than 650 public and private colleges, community colleges, universities, flagship universities, and other institutions across the United States. In addition, there are nine regional centers of excellence. As a program, LSAMP is responsible for more than 650,000 bachelor's degrees for underrepresented minority students in STEM, to date [National Science Foundation (NSF), 2018c]. LSAMP was largely an implementation program until 2016 when a research component became required. The results of the studies of these programs and their findings are now ready for publication.

The basic element of the LSAMP program is the alliance which is a collaborating group of colleges, universities and other institutions. For 30 years, alliances of the LSAMP program have been developing, testing and collecting data on successful activities. Since 2016, social scientists, education specialists and other researchers have been rigorously studying the best practices of LSAMP as part of a new initiative and many studies have matured to publication. The goal of this special publication was to collect these excellent studies in a single comprehensive volume. By having the LSAMP studies in one place, researchers from around the world have a single reference to consult.

## The Collection

This Research Topic contains 20 articles celebrating the impact of LSAMP and is centered around several main themes. The most common of these themes is transferring of LSAMP scholars from 2-year to 4-year programs or high school to college and the programs to support their transitions. The articles in this theme describe individual efforts with different examples, but they use unique methods to support transfers and their persistence in the new institutions. Sansing-Helton et al. elucidate the problems encountered in transfer from 2- to 4-year schools and report on the benefits of their Inspire program in Wisconsin. San Miguel and Gates describe a 2-year to 4-year transfer approach between two consortia, one composed of community colleges and the other of 4-year universities, that yields synergistic results in New Jersey. Gibson et al. described a hybrid but comprehensive transition program to help high school students enter college and community college students transfer to 4-year programs in Virginia. This study is one of several papers on summer experiences to prepare underrepresented minority students for the challenges of 4-year college programs. Ghazzawi et al. describe the long-term impacts of a focused summer bridge program on underrepresented minority students in STEM. Birkes et al. present an exploratory and descriptive study of a promising transfer bridge program from 2- to 4-year institutions in Georgia. The final article in this thematic group is by Barth et al. and it investigates the variability in summer bridge programs from high school to college in Alabama in terms of feelings of belonging and STEM self-efficacy.

Another major theme of the collection is the impacts and benefits of mentoring on the success of underrepresented minority students in STEM. The article by Markle et al. is a review of the benefits of structured mentoring on the success of underrepresented minority students in STEM. Kuchynka et al. describe the benefits of two mentorship and active learning interventions on high school and community college students in New Jersey. Beals et al. describe the benefits of an intensive peer and socio-emotional mentoring model for community college students and the development of a mentoring chain.

A third area of focus of the collection is the beneficial effect of undergraduate research experiences in both short and long-term. Research experiences are considered a best practice of the LSAMP program and, as a result, they are widely implemented. Several of the articles report on the benefits of international research experiences. One such article is by Benjamin et al. that describe the impact of the integration of international collaborative research experiences for underrepresented minority STEM faculty, students and graduates. It also credits the professional growth to the LSAMP Regional Center of Excellence that fosters these valuable experiences. Davis et al. document improvements in science identity, research competencies, and intercultural competence of LSAMP students international research experiences. Preuss et al. (B) document the quantitative benefits of international research experiences over a 14-year period at the Texas A&M LSAMP. Domestic research projects are also beneficial. For example, Betz et al. show the benefits of an 8-week research immersion summer program on transfer readiness of community college graduates who will attend Kansas State University the following semester. Preuss et al. (A) also describe the long term effects of undergraduate research at the Texas A&M LSAMP.

The other focus of the collection is on behavioral and social psychology research, models and techniques on improving and evaluating the success of LSAMP students. The article by Moreu et al. provide a review and techniques to develop a climate survey that allows researchers and practitioners to identify the methods to change learning climate. Similarly, Hargraves et al. provide the theory, development and testing of a new survey tool to evaluate the effectiveness of the LSAMP initiatives as tested in the Virginia-North Carolina LSAMP. The article by Garcia et al. describes the organizational brokerage theory and social capital needed by LSAMP scholars to succeed. The final article in this group may fit in another grouping. Miller et al. report on techniques and outcomes in a project using active learning to improve math scores in the emerging scholars program at West Virginia University.

Additionally, there are two articles on the impact of the COVID-19 pandemic and how it disproportionally impacted underrepresented minority communities in Illinois. These are very timely with regard to current events. The first paper is by Botanga et al. and investigates the role of systemic racism in dealing with the pandemic. The second paper is by Morgan et al. and it directly investigates the disproportionate impact of COVID on minority communities and how it is being dealt with.

## Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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## Conflict of interest

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# What's Your STEMspiration?: Adaptation and Validation of A Survey Instrument

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Millions of dollars each year are invested in intervention programs to broaden participation and improve bachelor degree graduation rates of students enrolled in science, technology, engineering, and mathematics (STEM) disciplines. The Virginia–North Carolina Louis Stokes Alliance for Minority Participation (VA-NC Alliance), a consortium of 11 higher education institutions and one federal laboratory funded by the National Science Foundation (NSF), is one such investment., The VA-NC Alliance partners implement evidence-based STEM intervention programs (SIPs) informed by research and specifically designed to increase student retention and graduation rates in STEM majors. The VA-NC Alliance is conducting an Alliance-wide longitudinal research project based in Social Cognitive Career Theory (SCCT) titled "What's Your STEMspiration?" The goal of the research project is to assess the differentiated impacts and effectiveness of the Alliance's broadening participation efforts and identify emergent patterns, adding to the field of knowledge about culturally responsive SIPs. In other words, "What's Your STEMspiration?" explores what influences and inspires undergraduates to pursue a STEM degree and career; and how does the development of a STEM identity support students in achieving their goals. In order to complete this research, the research team developed a survey instrument to conduct the quantitative portion of the study. Two preliminary studies, statistical analysis, and cognitive interviews were used to develop and validate the survey instrument. This paper discusses the theoretical and conceptual frameworks and preliminary studies upon which the survey is built, the methodology used to validate the instrument, and the resulting final survey tool.

**Keywords: STEM identity, self-efficacy, outcome expectations, survey instrument validation, cognitive interviews, social cognitive career theory**

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## INTRODUCTION

A 2015 study from the US Bureau of Labor and Statistics (Xue and Larson 2015) found that certain disciplines in science, technology engineering and mathematics (STEM) were in a labor market crisis because of a lack of trained professional in the workforce. Furthermore, specific regions experienced this crisis more acutely than others. The study found that in Virginia and North Carolina, the supply of STEM professionals (specifically B.S. degrees in engineering, cybersecurity, software developers, data science and those in skilled trades) currently does not meet the demand, particularly in industries that must hire US. citizens or permanent residents due to security issues. While there has been an increase of representation in some STEM occupations, women, and racial–ethnic minorities continue to be underrepresented in many STEM fields (Byars-Winston et al., 2015). For example, the number of racial–ethnic minorities completing bachelor's degrees in psychology, social sciences, biological, and computer sciences has increased over the past two decades. However, as observed by Fouad and Santana (2017), since 2000, underrepresented racial–ethnic minorities' graduation rates have flat-lined in engineering and physical sciences, and their numbers have dropped specifically in mathematics and statistics (National Science Foundation, 2017). The President's Council of Advisors on Science and Technology President's Council of Advisors on Science and Technology, (2012) articulates how the ongoing underrepresentation of certain racial and ethnic groups in the STEM fields continues to be a pressing concern for the nation. In order to address the challenges of the 21st century, particularly in the science and technology sectors, increased diversification of the United States STEM labor force is critical to enhancing the nation's competitiveness.

The Virginia–North Carolina Louis Stokes Alliance for Minority Participation (VA-NC Alliance) was established and funded to address the pressing need of broadening participation STEM. The VA-NC Alliance is a consortium of 11 higher education institutions and one federal laboratory funded by the National Science Foundation (NSF).[1] The VA-NC Alliance implements several types of intervention programs to increase the recruitment, retention, and graduation rates of students from underrepresented racial and ethnic groups in science, technology, engineering, and mathematics (STEM) fields[2]. For the purpose of this work, the research team will refer to individual program participants who identify as one of these groups as AALANAI (African American, Latinx American, Native American or Indigenous populations). These student participants are enrolled in community colleges, Historically Black Colleges and Universities (HBCUs), and predominantly white research institutions (PWIs) within the VA-NC Alliance. The VA-NC Alliance's overarching goal is to broaden participation in the STEM disciplines and contribute to the nation's critical need for a more diverse STEM workforce.

By preparing a workforce previously underrepresented in the STEM fields, the VA-NC Alliance is ensuring that diverse perspectives are applied to complex and global problems, benefitting its geographic region and the nation. The VA-NC Alliance partners implement evidence-based SIPs informed by research and specifically designed to increase student retention and graduation rates in STEM majors. The VA-NC Alliance partners' efforts to broaden participation in STEM include transition programs, tutoring, peer mentoring, speaker series, undergraduate research experiences, financial support (stipends), intrusive or targeted advising, academic monitoring, professional development workshops, and graduate school preparation, to name a few. While SIPs have shown varying degrees of success in improving academic achievement and graduation rates, a better understanding is needed regarding how such programs affect targeted students and improve (or do not improve) their chances of attaining a bachelor's degree. Since the inception of the Alliance in 2007, the number of STEM degrees obtained by AALANAI students from the partner institutions has increased by 285%. During this same time period, the number of AALANAI students enrolled in STEM disciplines at the partner institutions has increased by 210%. As a result of this success, the VA-NC Alliance is uniquely situated to conduct a research study to understand the specific impacts of the partner schools' environments and SIPs on students' persistence and STEM career goals.

Thus the VA-NC Alliance is conducting an Alliance-wide longitudinal research study to assess the differentiated impacts and effectiveness of the Alliance's broadening participation efforts and identify emergent patterns, adding to the field of knowledge about the impacts of culturally responsive STEM Intervention Programs (SIPs). The study explores the degree to which SIPs, cultural contexts, and personal inputs impact students' interests, goals, and actions pertaining to college retention, career decisions, and expected outcomes. The Alliance partners implement similar interventions, although tailored for their individual campuses, allowing the VA-NC Alliance an opportunity to conduct a longitudinal comparison study of the SIPs within the unique cultural contexts of each institution. A consortium such as the VA-NC Alliance provides a useful context in which to conduct this study. First, three different institutional types comprise the Alliance, allowing the research team to compare student experiences across these different contexts. The research team anticipates finding that there are strengths and needs within the different institutional contexts, informing their programming. Second, the Alliance provides access to a pool of AALANAI students and control groups to recruit for survey participation and later for focus groups and interviews. Third, the Alliance and its partner schools provide students with STEM intervention programs that would benefit from assessment in order to determine which programs are most impactful according to the data on outcomes and may be correlated with STEM students' academic and career achievements. This information would be useful for signaling the types of targeted interventions that institutions need to implement and funding agencies need to invest. This paper discusses the theoretical and conceptual frameworks for this research, the preliminary studies, the methodology used to validate the instrument, and the resulting final survey tool.

[1]The partner institutions are: Bennett College, Elizabeth City State University, George Mason University, Johnson C. Smith University, the National Radio Astronomy Observatory, Old Dominion University, Piedmont Virginia Community College, Saint Augustine's University, Thomas Nelson Community College, University of Virginia, Virginia Commonwealth University, and Virginia Tech.

[2]The NSF defines historically underrepresented racial and ethnic minorities in STEM as African Americans (or Black), Alaska Natives, Hispanic Americans (or Latinx), Native Americans, Native Hawaiians, and Native Pacific Islanders.

# OVERVIEW OF STUDY

The Alliance-wide longitudinal research study, "What's Your STEMspiration?", will provide additional understanding of the factors impacting AALANAI student academic success, retention, graduation and post-graduate career decisions in STEM disciplines at VA-NC Alliance institutions. The goal of the research project is to assess how students' personal inputs and sources of self-efficacy intersect with the differentiated impacts and effectiveness of the Alliance's broadening participation efforts. For this study, "STEMspiration" includes what influences and inspires undergraduates to pursue a STEM degree and career; and how does the development of a STEM identity support students in achieving their goals? The research team seeks to evaluate the effectiveness of interventions, identify differentiated impacts, and describe emergent patterns, adding to the field of knowledge about culturally responsive SIPs.

The study is based primarily on the theoretical framework of Social Cognitive Career Theory (SCCT) and investigates the underlying processes that impact AALANAI students' successful pursuit of STEM degrees and careers. Building upon existing theoretical frameworks and two preliminary studies conducted at VA-NC Alliance partner schools, the research team developed a survey instrument to identify specific areas to explore further in focus groups and interviews, increase knowledge pertaining to AALANAI STEM student success, and adapt Alliance programming as needed in response to the study's findings. Statistical analyses of pilot survey data and cognitive interviews utilizing the inductive methodological approach of grounded theory were used to validate the survey instrument.

## Theoretical Foundation

The "What's Your STEMspiration?" theoretical framework builds upon the work of Vincent Tinto, John C. Weidman et al., Martin M. Chemers et al., and theorists associated with Social Cognitive Career Theory. The foundation for the development of the NSF's Louis Stokes Alliance program was Tinto's model of student retention, which emphasizes the academic and social integration of students into the institution (Tinto, 1987) In its early years, the VA-NC Alliance relied on the Tinto model for its program design. As the Alliance's research study team formed in 2017, members broadened their understanding of student identity through Weidman's concept of disciplinary socialization, a process by which students build community and develop interpersonal relationships with those within their discipline (Weidman et al., 2014). Given the Alliance's study would focus on self-efficacy, STEM interventions, outcome expectations, and identity, the research team turned to Chemers et al. (2011) to consider the mediation model of the effects of science support experiences. A model in which various support components affect relevant psychological processes, which in turn lead to commitment to and involvement in a scientific career. With the inclusion of sources of self-efficacy and the career development process in the study, the research team turned to the work of Byars-Winston et al. (2010) and others associated with Social Cognitive Career Theory (SCCT). This theory postulates that students' interests, choices, and performance are impacted in some way by contextual factors throughout the lifelong academic and career development process. SCCT considers the influence of self-efficacy, outcome expectations, identity, goal attainment on academic and career interests, and goal setting (Bandura 1986; Lent R. W. et al., 2005; Usher and Pajares, 2008; Byars-Winston et al., 2010; Navarro et al., 2014; Lent R. W. et al., 2015; Byars-Winston et al., 2016; Dickinson et al., 2017). As Fouad and Santana stated:

> The SCCT (Lent R. W. et al., 1994; Lent R. W. et al., 2000) has continued to be the major theoretical framework investigating factors that have contributed to the underrepresentation of women and racial–ethnic minorities in STEM fields. This has continued to be an area of investigation because there have been consistent race and gender disparities at the educational and occupational levels in STEM professions, even 35 years after Betz and Hackett (1981) began to study it. SCCT has also been used as a frame to examine all of the empirical studies in the past 40 years that have examined gender differences in STEM careers (Kanny et al., 2014), primarily because the model explicitly incorporates gender as a person input and explicitly includes contextual influences at proximal and distal levels (Fouad and Santana, 2017, 26).

The SCCT interest model (focuses on the role of individual interests in motivating choices of behavior and skill acquisition) and choice model (holds that interests are typically related to the choices that people make and to the action they take to implement their choices) utilize self-efficacy in a particular domain, outcome expectations, and interests as well as proximal and distal experiences to explore factors that influence career choices. Studies over the past four decades (Betz and Hackett 1981; Hackett and Betz 1989; Betz and Schifano 2000; Ferry et al., 2000; Fouad and Byars-Winston 2005; Carlone and Johnson 2007; Hurtado et al., 2009; Blake-Beard et al., 2011; Lent R. W. et al., 2011; Johnson et al., 2012; Flores et al., 2014; Navarro et al., 2014; Alhaddab and Alnatheer 2015; Lent R. W. et al., 2015; Dickinson et al., 2017; Fouad and Santana 2017) have examined the fit of the SCCT interest and choice models among college students and have shown that building self-efficacy in a STEM related domain (mathematics, science, etc.) and fostering the development of positive and realistic outcome expectations for entering a STEM career would lead to interests in STEM related activities, in turn, lead to STEM career goals and preparation for, and entry into a STEM career. Furthermore, the SCCT framework incorporates contextual factors, such as research experiences, mentoring, interventions programs, etc., in understanding the underrepresentation of certain populations in STEM careers. As stated in Fouad and Santana, "Using an SCCT framework allows us to understand the complexity of factors and opportunities for intervention presented along a career trajectory. SCCT can also be an asset to those working in direct practice, as it points directly to areas where intervention can facilitate the decision-making process" (Fouad and Santana, 2017, 27). "In sum, SCCT has been instrumental in investigating undergraduate women and underrepresented minorities' career interests, choice, and persistence while pursing STEM majors" (Fouad and Santana, 2017, 32).

Building on the work of Tinto, Weidman, and others, the "What's Your STEMspiration" survey instrument specifically incorporated existing SCCT measures (Byars-Winston et al., 2010) and mediation model measures (Chemers et al., 2011). Chemers et al. examined how psychological factors, such as self-efficacy and personal identity, mediated the relationships between science support experiences (i.e., research experience, mentoring, and community involvement) and desirable outcomes (i.e., commitment to and effort expended toward a career in scientific research). Byars-Winston et al. (2016) composed and validated a survey instrument based on SCCT that examined the internal reliability and factor analyses for measures of research-related self-efficacy beliefs, sources of self-efficacy, outcome expectations, and science identity. The "What's Your STEMspiration?" study responds to the call from Byars-Winston et al. (2010) for additional research into how cognitive, cultural, and contextual characteristics indirectly influence AALANAI STEM students' outcomes and from Fouad and Santana (2017) to examine if there are some contextual supports (professors, financial aid, mentors, or research experiences) more important for some groups than others and if there are key intervention points that would effectively prevent college attrition in STEM majors.

The "What's Your STEMspiration?" study is also built upon two preliminary research studies that focused on undergraduate recruitment and retention conducted within the VA-NC Alliance at partner schools, Virginia Commonwealth University (VCU) and the University of Virginia (UVA). The VCU study focused only on its Louis Stokes Alliance for Minority Participation (LSAMP) activities and utilized an emergent mixed-methods design including a survey instrument and focus groups. The UVA study, qualitative in nature, was a VA-NC Alliance wide study and utilized participant interviews. The results from these two preliminary studies informed the development of the survey instrument for this longitudinal study. Overviews of these two studies are provided below.

## Virginia Commonwealth University Preliminary Study: An Exploration of Factors Influencing VCU LSAMP Students' Decisions to Stay in STEM

The VCU LSAMP program offered various STEM SIPs over its fourteen-year history, including transition programs, research experiences, mentoring, scholarship programs, etc., that engage undergraduate AALANAI STEM majors. During that time, the VCU LSAMP team has conducted studies and evaluations to improve program outcomes (Alkhasawneh R. and Hobson, 2009; Alkhasawneh R. and Hobson, 2010; Alkhasawneh, R. and Hobson 2011; Alkhasawneh R. and Hargraves, 2012; Brinkley et al., 2014; Alkhasawneh R. and Hargraves, 2014; Griggs et al., 2016). In 2015, the VCU team conducted a preliminary research study on the design and implementation of the VCU LSAMP Hybrid Summer Transition Program and accompanying intervention programs, and to facilitate student academic and social integration into VCU. The team developed a 63 item survey instrument to investigate: 1) factors that contributed to retention and academic success for their LSAMP students; 2) the impact of the summer transition program on student retention and academic success, as well as its impact on first year success; and 3) the role existing STEM intervention programs played in student academic integration, social integration, and career preparedness. The survey was developed from existing publicly available surveys that assessed academic and social integration and was informed by Tinto's model of academic and social integration (Tinto, 1987), Strayhorn's model of sense of belonging (Strayhorn, 2012, Strayhorn, 2018), and Bourdieu's cultural capital model (Bourdieu, 1986).

At the time of the study, all 154 students in the VCU LSAMP program were invited to participate after the study received IRB approval (HM#20001406). The survey findings provided areas of focus for the qualitative portion of the study, which used focus groups and interviews with targeted students to explore the extent to which SIPs have influenced their perceptions of issues deemed crucial to academic success. Two focus groups were conducted and 10–12 students, current or former STEM majors who had participated in one or more LSAMP SIPs, took part in the focus groups.

The VCU study identified activities and factors important to the academic and social integration of the LSAMP students and their sense of belonging in a STEM field. These findings informed areas of inquiry for the "What's Your STEMspiration?" survey instrument. This VCU study also provided insight into specific response options for certain survey questions (see *Model Development and Pilot Survey Instrument*). In summary, regarding STEM related academic support activities and STEM intervention programs, students expressed willingness to attend peer mentoring sessions and career/professional development events; thus warranting exploration in the Alliance-wide study However, students were less likely to take advantage of university sponsored SIPs, such as tutoring, academic coaching, visiting the writing center, or even meeting with a faculty member during office hours; thus warranting possible exclusion in the Alliance-wide survey. While students felt positively about the social interactions they had with other students in their program and their choice in academic major, they were neutral about their faculty members' knowledge about their future. No statistically significant relationship emerged between the examined sense of belonging and academic capital variables and students' GPAs. When exploring students' plans for the future, the most highly indicated reasons for remaining in STEM were personal interest, aptitude, as well as employment and salary opportunities. However, the most commonly cited reason for considering leaving STEM was unappealing employment opportunities. Further findings from the VCU LSAMP preliminary study are explored in Griggs et al. (2016).

## University of Virginia Preliminary Study: An Exploration of LSAMP Students' Experiences and Future Plans

The UVA study was designed to test qualitative research protocols as well as inform the development of the "What's Your STEMspiration?" survey instrument's questions and response options, prior to conducting the broader Alliance-wide research study.[3] After receiving IRB approval (SBS # 2017021800), the research team conducted interviews over a period of three months with a goal of interviewing two students from each of the partner schools (nine schools at the time of this preliminary study) for a total of eighteen interviews. Using an online randomization tool called Research Randomizer[4], the research team randomly selected participants representing each of the schools from the 2017 VA-NC Alliance Annual Undergraduate Research Symposium registration database listing students and their home institutions. In the recruitment email, the research team members informed students that their participation in this study was completely voluntary. Despite offering the incentive of a $20 gift card from Amazon for each participant, the team recruited fifteen rather than eighteen participants for the interviews. Respondents were de-identified using pseudonyms and findings reported in aggregate, keeping participant identities confidential.

Based on the interview transcripts, a set of codes with definitions were drafted by each research team member and revised until consensus was reached. Then, the transcripts and codes were entered into Dedoose. Out of 17 parent codes, the ones applied the most often to transcript excerpts were the following, in descending order: "support network," "career goals/aspirations," and "academic opportunities" (see **Figure 1**). Interviewees described a variety of support networks, including family, friends in the residential halls who were also struggling with STEM courses, professional organizations, peer mentors, graduate students, faculty, and research labs. Analysis of the surveys revealed the importance of mentors for students. Some students from Bennett College noted that they have multiple mentors. Others such as a student from Saint Augustine's University shared how academic opportunities impacted her career goals/aspirations, saying that the undergraduate research symposium she attended was

> "really an eye-opener for me because I was able to surround myself with people who think like I do, and people who have done work in areas that I didn't know before, and sparked interests in areas that I would have never knew [sic] if I didn't go . . . That's the role it played for me, is really an eye-opener into reality and what other scientists are doing across the nation."

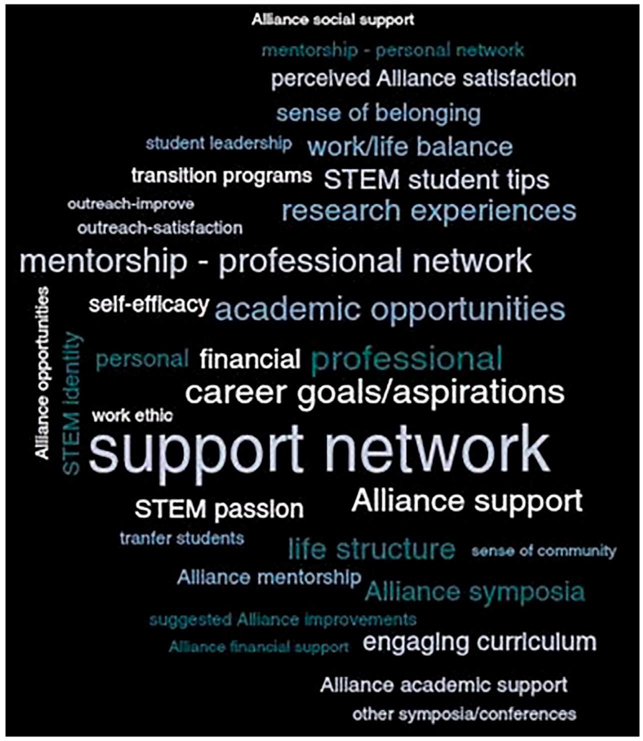


**FIGURE 1** | VA-NC alliance pilot study code word cloud.

Analysis of how the codes intersected with each other clarified for the research team that it would be necessary to utilize factor analysis in the Alliance-wide study in order to understand how numerous variables interact.

The UVA preliminary study identified activities, topics, and themes important to the interviewees - these informed areas of exploration for the Alliance-wide research study to prioritize and incorporate into its survey instrument. Furthermore, the analysis of these results demonstrated how various forms of academic and social support were interconnected in students' minds. This informed the structure of the subsequent and broader Alliance wide research study's survey questions, response options, and analysis. Development of the broader Alliance-wide survey instrument is discussed in *What's Your STEMspiration? Instrument Development.*

# WHAT'S YOUR STEMSPIRATION? INSTRUMENT DEVELOPMENT

## Model Development and Pilot Survey Instrument

Using the instrument from the VCU preliminary study and the findings from the UVA preliminary study, a pilot survey was developed for a VA-NC Alliance-wide longitudinal research study. The purpose of this study was to better understand the factors impacting academic success, retention, graduation, and post-graduate career decisions for students in STEM of

[3]At the time of the UVA study, the VA-NC Alliance included the following partner schools: Bennett College, Elizabeth City State University, George Mason University, Johnson C. Smith University, Piedmont Virginia Community College. St. Augustine's University, University of Virginia, Virginia Commonwealth University, and Virginia Tech.

[4]https://www.randomizer.org/

the VA-NC Alliance. The survey instrument was composed of associated factors mapped to ten content areas categorized in a two-tier model. This two-tier conceptual framework segments the study's exploration of factors influencing student retention and career decisions into five factors in each of the two tiers, as shown in **Figure 2**.

The first tier, labeled as the "Initial Input" tier, involves multiple factors including sources of self-efficacy, personal inputs, academic environments, STEM intervention programs, and mentors. Bandura et al. (1999) hypothesized that there are four sources of self-efficacy: mastery experiences, vicarious experiences, verbal and social persuasions, emotional and psychological states. These experiences and states of being influence students' self-efficacy in the three domains explored in this research (academic-related self-efficacy, research-related self-efficacy, and STEM-career self-efficacy), thus our model incorporates sources of self-efficacy. For this study, personal inputs are defined as those experiences and distal and proximal contextual affordances that may have played a role in the students' choice of major or desire to pursue a STEM career (Lent R. W. et al., 2000). While sources of self-efficacy may include personal inputs, this study specifically identifies personal inputs as a factor and includes social identities, academic information (e.g., major, GPA, institution, etc.), and previous experiences that may have contributed to the student's choice to pursue a STEM degree. To explore the impact of student participation in STEM intervention programs and the nuanced differences in students' experiences at different institutions, i.e., community colleges, HBCUs, and PWI academic environments, both SIP participation and academic environment are included as input factors. Common themes that emerged from the interviews conducted for the UVA preliminary study included "support network" and "mentoring," thus it was important to include mentoring as a stand-alone input factor in the "Initial Input" tier.

Prior research guided the selection of the five associated factors of the "Student Development" tier of the model, which included research-related self-efficacy, academic-related self-efficacy, STEM-career self-efficacy, STEM identity, and student outcome expectations. Self-efficacy is a central tenet of Social Cognitive Career Theory (SCCT) and is shown to influence students' choices of career paths, including STEM (Byars-Winston et al., 2016). Dickinson et al. (2017) also reported harmful academic treatment towards African American students may discourage undergraduates from taking classes to prepare for STEM careers, therefore, negatively affecting self-efficacy and outcome expectations. Given that several VA-NC Alliance students noted that they either participate in research experiences or internships, it was important to include research-related self-efficacy and STEM-career self-efficacy in the "Student Development" tier in addition to academic-self-efficacy. Academic self-efficacy refers to one's perceived capability to perform given academic tasks at desired levels. Academic self-efficacy is often conceptualized as a domain-specific construct, and its relationships with various achievement indexes have frequently been probed in the context of carrying out a specific task of interest (Bong, 1997). Research-related self-efficacy (or research self-efficacy) is defined as one's confidence in successfully performing tasks associated with conducting research (e.g., performing a literature review or analyzing data) (Forester et al., 2004). STEM-career self-efficacy is defined as one's belief in one's ability to successfully pursue a STEM career and perform the job functions required by that career (Milner et al., 2014).

Researchers have also examined the role of science identity in students' persistence in STEM. When students feel as if they are

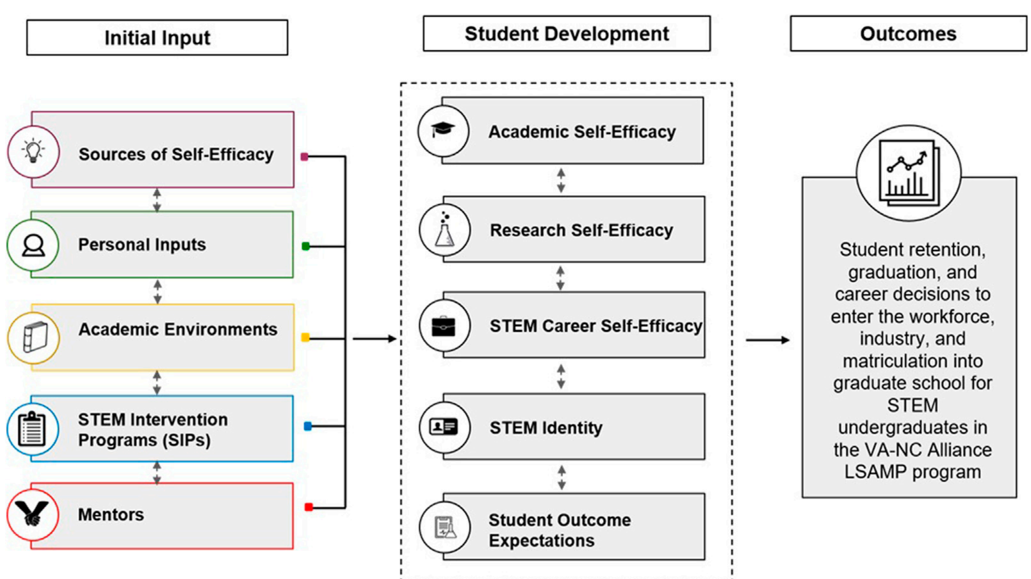


**FIGURE 2 |** Survey instrument model of the effects of associated factors for student retention and career decisions in the VA-NC alliance program.

scientists then they are more likely to pursue careers in the field (Estrada et al., 2011). Given the VA-NC Alliance includes majors beyond science including engineering, agriculture, technology, and mathematics, it was important to explore not just science identity, but STEM identity. As a result, the research team chose to include STEM identity broadly as a factor in the "Student Development" tier. In fact, because students are pursuing interdisciplinary career interests and are finding that the traditional disciplinary boundaries are fading, students may be more likely to see themselves as part of a broad STEM community not just as a scientist, engineer, mathematician, or technologist.

As illustrated in **Figure 2**, the research team hypothesized that the initial inputs represent factors that directly shape student development factors in the second tier: academic self-efficacy, research self-efficacy, STEM-career self-efficacy, STEM identity, and student outcome expectations. The research team also hypothesize that factors within a tier are interdependent and possibly influence other factors within the tier. For example, academic self-efficacy could influence STEM-career self-efficacy. For the pilot survey, behavioral questions were included to account for any influences that may have contributed to a student's academic performance, support, and well-being, such as employment, family obligations and engagement, transportation (i.e., commuting from job, school, or class), involvement in academic activities outside of class, time for study, use of social media, and physical activity (i.e., university athletics, intramural sports, physical recreation). The pilot survey included most of the questions from the VCU survey instrument in addition to new questions regarding research self-efficacy, STEM career self-efficacy, STEM identity and mentoring. These questions were added based upon the findings of the UVA interviews and to fit into the proposed model. What began as a SCCT model emerged into a nuanced model appropriate for this study; however, as a result of the additional questions, a 63-item survey instrument evolved into 103 questions. Although respondents did not have to answer all questions, because of branching logic, the instrument became much longer.

## Testing the Validity of the Pilot Survey Instrument – Statistical Analysis

To test the pilot survey instrument before submitting to a wider distribution of students, surveys were directly distributed to participants of the VCU LSAMP program and the Elizabeth City State University (ECSU) LSAMP program. Contact information for the VCU and ECSU LSAMP participants had been previously made available by the program staff. In total, more than 350 students and alumni from the two programs were invited to participate. Study data were collected and managed using REDCap[5] (Research Electronic Data Capture), a secure web application tool used to design and administer surveys and research databases hosted by VCU.

Traditionally, mixed methods research aids in the validity of a study through triangulation, whereby generalizable findings of quantitative research are enhanced by contextual understandings in the qualitative. But this method of validation is generally attributed to checking the results, and not necessarily verifying that the instrument is really measuring what it is intended to. The research team desired to validate the instrument using statistical analysis. However, after several months of eliciting responses, only 49 completed survey responses had been collected, even after extending the initial deadline an additional two months and after sending additional requests to the VA-NC Alliance students.

The research team noted that there were also a high number of partial responses (approximately 50%), raising concerns about the potential effect of survey fatigue. Subsequently, the research team discussed the estimated time of 15–20 min for completion of the survey, based on preliminary testing by the coordinators of the VA-NC partner schools. They also took note of the survey instrument's 243 separate survey questions when all branching was considered. Upon a closer review of the partial responses in REDCap, a clear drop out pattern did not emerge; some participants would stop about halfway through the survey, while others would be close to finishing before they stopped. The research team then discussed the option of conducting cognitive interviews to evaluate the survey instrument's feasibility, simplicity, and time required. Ultimately, the research team decided to first run a principal component analysis (PCA) in SPSS (Statistical Package for the Social Sciences) to confirm that the factors represented in the survey are the ones that the research team were ultimately trying to measure. This method of analysis would also assist the research team in identifying poor performing items based on quantitative summaries of data, to help aid in the decision regarding reducing the number of questions.

Before performing the PCA, the research team discussed in detail the questions and their intended mapping with the study's proposed model (**Figure 2**). During this process, the research team recognized that parts of the measure were adapted directly from other instruments (Byars-Winston et al., 2010; Chemers et al., 2011; Byars-Winston et al., 2016). Therefore, the research team decided to focus the analysis on the questions that were newly created/added for this study's focus, and that served as indicators of attributes in the Student Development tier (**Figure 2**). Survey questions were then grouped according to these five factors: Academic Self-Efficacy, Research Self-Efficacy, STEM Career Self-Efficacy, STEM Identity, and Student Outcome Expectations. Only completed survey responses were included, but zeros for any non-applicable responses remained. Missing data for completed surveys (e.g., where the question was skipped in branching) was replaced with the column mean (which was 0 for any instances of this), to avoid errors when running the data. A principal component analysis was then performed with Varimax (orthogonal) rotation using SPSS software to test the five factor structures identified.

The analysis yielded five factors explaining a total proportion of 48.96% of the variance for the entire set of variables. The communalities of the variables included are rather low overall, which would indicate that the variables chosen for this analysis are only weakly related with each other. However, the correlation matrix showed that most items had some correlation with each other, ranging from r = −0.7 to $r = 0.966$. All questions did load

[5]https://www.project-redcap.org/

**TABLE 1 |** Summary of SPSS and MPlus analyses.

| | Academic self-efficacy | Research self-efficacy | STEM career self-efficacy | STEM identity | Student outcome expectations |
|---|---|---|---|---|---|
| **SPSS** | | | | | |
| # Items in scale | 4 | 6 | 9 | 10 | 5 |
| *N* in SPSS file | 49 | 41 | 25 | 48 | 72 |
| Cronbach alpha | 0.72 | 0.80 | 0.93 | 0.85 | 0.74 |
| **MPlus** | | | | | |
| Chi-square with df, *p* | (2) = 3.77, $p = 0.15$ | (9) = 12.72, $p = 0.18$ | (27) = 70.94, $p < 0.001$ | (35) = 145.40, $p < 0.001$ | (5) = 26.61, $p < 0.001$ |
| | 0.115 (0, 0.293) | 0.098 (0, 0.212) | 0.255 (0.184, 0.328) | 0.244 (0.204, 0.286) | 0.239 (0.153, 0.335) |
| RMSEA (90% CI) CFI | 0.973 | 0.947 | 0.814 | 0.557 | 0.790 |
| SRMR | 0.051 | 0.085 | 0.142 | 0.136 | 0.092 |
| Notes: | | One item has a lower factor loading than other items. | | | One item had a lower factor loading than the other items. |

onto a factor(s). To review the internal consistency of questions that load onto the same factors, Cronbach's Alpha (CA) was used. Scores ranged from 0.72 to 0.93 (**Table 1**), indicating that question reliability was good and the scales were acceptable. However, with recognition that communalities of the variables were rather low, and that this type of analysis does not give information about significant cross-loadings, the research team decided to conduct a Confirmatory Factor Analyses (CFA) using Mplus (**Table 1**).

Prior to conducting the analysis in Mplus, all responses were pulled (partial and full responses) and variables were re-coded to ensure the variables had not been flipped. Information regarding overall results can be found in **Table 1**. The model for STEM Identity terminated normally, although one item was not significant and the overall model fit was poor, likely due to the low power, or the small *N*. The small *N* made it difficult to test the STEM Career Self-Efficacy scale with CFA, however the Cronbach alpha was high, indicating this construct is reliable as one measure. The small *N* may have also impacted the testing of the Academic Self-Efficacy scale, as the residual covariance matrix was not positive definite, which could indicate a high correlation between variables of dependency. However it is difficult to be certain with the small sample size. Most of the MPlus indicators of model fit, with the exception of the Research Self-Efficacy Scale, which did not meet acceptable scientific levels. Ultimately, the results of this different approach to the analysis did indicate that two questions had low factor loadings (see **Table 1**), and a change to the question, "previously you indicated that you are considering changing your major," which mapped to Student Outcome Expectations, was needed. Specifically, descriptive information provided that nine of the 13 items went unchecked each time, resulting in a lot of zeros, which impacted the reliability of the factor analysis. Therefore, the wording of the question was changed to "please explain why you are considering changing your major," followed by a fill-in-the-blank field. In considering the findings for this question using Mplus, the research team also noted the need for a review of, and some revisions to, any multi-item questions.

Overall, the research team concluded that running the factor analyses on the data that was available did provide some beginning information, but not enough to adjust any additional items in the survey. The results in both analyses conducted in SPSS and Mplus were similar, leaving the research team confident that they were not missing factors in their model. In short, the desired domains are being captured, and the reliability of the instrument is good. However, this does not equal validity, and there were not enough data to conduct a solid analysis or decide which questions could be removed to see if that would help with the low response rate. Therefore, the research team revisited the idea of conducting cognitive interviews in order to firmly identify sources of confusion in assessment items, and to assess validity evidence based on content and response processes.

## Testing the Validity of the Pilot Survey Instrument - Cognitive Interviews

The research team decided to conduct cognitive interviews to ensure survey respondents understood the questions as they were intended, respondents could provide and recall accurate answers across the time periods in the survey, determine if respondent experiences were missing from the survey, and that response options captured respondents' experience. In addition, the team wanted to determine if the survey items supported the survey constructs surrounding self-efficacy.

### Cognitive Interview Methods

Seven students from one partner university were invited to participate in the cognitive interviews and five female LSAMP students consented, including one freshman and one senior. A team member conducted the cognitive interviews via Zoom with responses captured by another team member through extensive notes. Interviews took approximately 60 min. At the start of the interview, interviewees were emailed a copy of the survey in a PDF format with the questions to be tested highlighted in yellow. The interviewer used "think aloud talk aloud" and probing methods to elicit responses that allowed the team to understand how interviewees conceptualized the questions and the source of their answers.

At the end of the cognitive interview, interviewees were asked questions about the overall purpose of the survey. Specifically, the interviewee was reminded of the concepts of self-efficacy and STEM identity and then asked the following meta questions:

- What does STEM identity mean to you? *Or* In what way do you feel you have a STEM identity?
- How well do you feel this survey asked you about your own perseverance, determination, or any barriers you have overcome as a STEM student? *Or* What has helped you to create an ability to overcome obstacles and succeed as a STEM student?

Following the grounded theory framework for data qualitative analysis, interview notes were loaded into Dedoose for blind coding by three team members. A coding index based on the four broad cognitive interview categories and a set of child codes were developed. The four parent codes were:

- Understanding: interviewee had issues understanding the question, terms, concepts, or misinterpreted the question.
- Recall: the interviewee had limited knowledge or experience to answer the question; had difficulty remembering the time-period; or could not do the mental calculations to answer the question (e.g., hours, number of times, etc.).
- Response: the interviewee could not find a response option that reflected their experience; response options were not mutually exclusive.
- Judge: the interviewee found the question sensitive; did not give an honest response; or the question or response options were not relevant.

The child codes specified the challenge or issue interviewees had with the question. For example, if interviewees could not find a response option that met their experience, the item was coded as "RESPNSMISS" for response missing. Responses from the STEM identity questions were coded as "STEMID = " and paired with a child code to describe the meaning of STEM identity for that interviewee. This parent code was also used at any point during the interview when interviewees described or discussed their STEM identity. Sources of self-efficacy were coded as "SESOURCE = " with a child code for the source, linking back to the literature. Like STEM identity, this parent code was used throughout the interview anytime an interviewee discussed a source of self-efficacy. This data set was analyzed separately, and recommendations made to the team regarding changes to survey items.

Dedoose Memos were used to categorize the types of changes being recommended by interviewees. The following memo categories were used:

- Add: add a response option or question
- Change: make a change in the survey structure or question structure
- Clarify: change the language used to clarify a time-period, a term, a response option, or the instructions
- Rephrase: rephrase the question or a response option
- Two additional Memo categories were created:

o Question: a memo that contains a question for the team (these were not analyzed but discussed by the team)
o STEMID: a description or memo related to the STEMID =, or SESOURCE = codes further explaining how the interviewee's view of their identity or source of self-efficacy links to the literature or is connected to other interviewees' understanding of the survey construct

Three team members blind coded all the interviews. The team then reviewed the coded interviews to identify items where coding did not agree. The team then reviewed and discussed the few instances (1.72%) where codes differed among the team, comparing the items to others in the code group to determine which code to use. The results of the CI analysis were then mapped onto the survey questions with recommendations for changes based on the analysis.

### Results of the Cognitive Interviews

Overall, the cognitive interviews revealed the survey needed adjustment due to interviewee understanding, recall, and response option challenges. Questions, terms, and response options needed to be clarified or rephrased due to assumptions, confusing terms, missing elements, and generational language differences in the questions and response options. In addition, the interviews revealed student STEM identity began in high school, however, the survey did not include this time-period in questions or response options. As a result, interviewees felt they could not accurately answer many questions.

More broadly, responses to the meta questions showed interviewees felt the survey was about their study habits, not their self-efficacy. Because of this perception, they reported answering many questions based on how they wanted *faculty* to see them vs. how they saw themselves or the actual actions they had taken. As a result, interviewees reported other students would not answer questions honestly. In addition, they pointed out the survey lacked questions about their belief in themselves, their perseverance or persistence, and any obstacles they had faced as a STEM student. During the interviews, students described many challenges they had overcome and how their own persistence had helped construct their academic self-efficacy. Even though the survey generated these memories as part of their answering process, the instrument was not capturing or measuring these aspects of academic-related self-efficacy or STEM identity.

Two students noted their source of self-efficacy came from their own agency, which included changing their current STEM major to another STEM major they "enjoy" more, which also better suited their long-term career goals. This suggests that changing your major may not be a barrier to academic-related self-efficacy but rather a source of self-efficacy depending on the student's view of themselves as either active agent (changing it to suit personal goals) or passive participant (changing because their grades are low or because of parental pressure).

Interviews also showed academic self-efficacy waxed and waned depending on the time of the semester and the class status of the student when they took the survey. Interviewees who were juniors or seniors noted they felt very confident in their self-efficacy because they were close to graduation. This raised a question regarding how student graduation dates might influence the data.

## Case Study: Mentors and Academic Self-Efficacy

Although the survey asked questions about mentors, CI interviewees found these questions confusing, jargon-laden, or could not find an adequate response option to answer the question based on their experience. This section provides a case study of the changes made to questions and response options related to mentors.

The survey used the term "mentor" throughout, however, only defined it in the question specifically dedicated to mentoring toward the end of the survey. The cognitive interview process revealed interviewees' definition of the term mentor included role models, or people who had inspired their interest in science. For example, one interviewee considered her African American female pediatrician a mentor. The student had looked up to this woman as a young girl and described how the pediatrician contributed to her STEM identity, but the experience described a role model.

Another question grouped having mentors under academic services and opportunities (Which of the services or activities listed below did you take part in or use during your undergraduate career?). Interviewees noted this formalized the mentoring process as a university sponsored activity, which did not reflect their experience. As a result, they did not report having mentors in this question. Therefore, these response options were removed from the question.

The primary question on mentoring asked interviewees to indicate their level of agreement with a series of statements about their experience being mentored using a five-point scale. Cognitive interviews showed that mentors from high school had significant influence over student decisions about college and majoring in STEM and continued to be mentors for these

**TABLE 2 |** Original survey question and statements with the feedback from interviewees, and the initial suggested change.

**Original survey question: Thinking about your mentoring experiences, please indicate your level of agreement relating to the following aspects of mentorship. Please note, mentors can be anyone that has given you individual support in relation to your development as a STEM student or STEM professional.**

| Original survey response | Interviewee feedback | Changes recommended |
|---|---|---|
| I have had access to valuable faculty and/or staff mentors at my home institution | "Access": Does not mean they were a mentor; you can have access to them but still not have a mentor.<br>"Valuable": Having a mentor and having a good mentor are different questions<br>"Home institution": Confusion about meaning<br>"Staff": Rarely interact with staff | Rephrase: I have/had faculty mentors at my current undergraduate institution |
| I have had access to valuable peer mentors at my home institution | Same comments as above | Rephrase: I have/had peer mentors at my current undergraduate institution |
| I Have had access to valuable mentors in my family | Same comments as above missing: Religious community, family friends, high school teachers | Rephrase: I have/had mentors in my family<br>Add: I have/had mentors from my community, such as religious leaders or family friends |
| I have had access to mentors outside of my home institution | Same concerns about "access", "home institution"<br>Missing; response options about high school mentors | Rephrase: I Had mentors who encouraged me to pursue STEM prior to attending my current undergraduate institution (for example mentors in high school or earlier). |
| I Look up to my mentor(s) as career role models | "Career": Not all mentors are in STEM though they contribute to STEM self-efficacy | Rephrase: I Look up to my mentor/s as role models. |
| A mentor in my home institution helped me develop the skills I need to be successful in a STEM career | "Home institution": Confusion about meaning<br>"Successful": Subjective, defined differently by each interviewee. Could not predict the future | A mentor at my current undergraduate institution helped me develop the skills I need to have a career in STEM. |
| A mentor outside my home institution encouraged me to pursue a STEM career | "Home institution": Confusion about meaning<br>"Missing": Response option for high school mentors<br>"Pursue a career": Major in STEM in college | A mentor from outside my current undergraduate institution, such as my high school, encouraged me to major in STEM |
| It is important to me that at least one of my mentors is of the same race/ethnicity, gender or other social identity as I am. | Generally, yes. But students want to learn from anyone who is willing to help them. | N/A |
| At least one of my mentors was of the same race/ethnicity, gender or other social identity as me | None | N/A |
| Faculty in my department have provided a great deal of guidance to help me be successful in my major | "Great deal": Too subjective, confusion about meaning, i.e., quality vs. quantity. "Do you mean helpful?"<br>"Successful": Subjective, defined differently by each interviewee. Could not predict the future | Faculty in my department have provided guidance to help me in my major |
| There are faculty role models in my department | "Probably" but this does not mean they are my role models; statement is too vague | Rephrase: I Have faculty role models in my department |

**TABLE 3 |** Sample of finalized survey questions.

| Associated factor | Survey questions: |
|---|---|
| Personal inputs and academic environment example questions | What is your cumulative undergraduate GPA as of the last semester you completed?<br>Are you the first in your immediate family to go to college?<br>Are you a US citizen or permanent resident?<br>Are you a participant in the LSAMP program? -with branching logic<br>Which factors do you feel contributed to your decision to pursue a major in a STEM field? (Please select all that apply) -with branching logic |
| Sources of self-efficacy example questions | I feel/felt like I belong in my undergraduate college or university. Why or why not?<br>I feel/felt like I belong in my undergraduate major. Why or why not?<br>I can recognize my own academic limitations and areas where I need help.<br>When I realize/d I need/ed help, I seek/sought assistance from available resources such as peers, tutors, classmates, faculty, TA's, or mentors. |
| Academic self-efficacy example questions | Thinking about the skills gained from your undergraduate courses, please indicate your level of confidence relating to:<br>● Analyzing data (quantitative or qualitative)<br>● Solving problems<br>● Using software relevant to my field (e.g., Excel, Java, Labview, Matlab, Python, Solidworks, SPSS, etc.)<br>● Using technical skills and/or techniques relevant to my field |
| Research self-efficacy example questions | Thinking about the research experience you described in the previous question, please indicate your level of confidence relating to:<br>● Using scientific literature and/or reports to guide research.<br>● Generating a research question to answer.<br>● Figuring out what data/observations to collect and how to collect them.<br>● Working on research teams. |
| STEM- career Self-efficacyExample questions | Thinking about the internship experience you described in the previous question, please indicate your level of confidence relating to:<br>● Communicating professionally (e.g., emails, memos, presentations, etc.)<br>● Developing a work plan implementing relevant organizational procedures<br>● Solving "real world" problems<br>● Working in a professional (office, field, healthcare, etc.) setting |
| SIP<br>Participation example questions | There are a variety of opportunities offered through LSAMP designed to help students succeed in STEM-related majors. Please reflect upon your participation in these specific programs. Which of the activities did you attend or participate in at any time during your undergraduate career? (Please select program all that apply) -with branching logic |
| Mentoring example questions | Thinking about your experience being mentored by the people listed in the previous question, please indicate your level of agreement with the following aspects of mentorship (please select all that apply).<br>● Modeled how to overcome challenges and reach personal goals.<br>● Showed me how to treat failed attempts as a learning experience.<br>● Gave me the sense s/he and I shared similarities of background, personality, or other important personal characteristics.<br>● Helped me overcome insecurities about my abilities as a STEM student, if I had any. |
| STEM identity example questions | Reflecting on your undergraduate experience, please indicate your level of agreement with the following statements:<br>● I feel like I identify as a scientist, technologist, engineer, or mathematician<br>● I feel like I am part of a STEM community.<br>● I have a passion for my STEM coursework/curriculum content.<br>● My hobbies and interests are often STEM related.<br>● My personal abilities/talents are a good "fit" with requirements in STEM. |
| Outcome expectations example questions | I have a passion for the work I can do with my STEM degree.<br>How confident are you in starting a successful STEM career?<br>My career plans for the future are to: -wth branching logic<br>My academic plans for the future are to: -with branching logic |

students during college. However, these high school mentors were not reflected in the statements for the mentoring question nor were they reflected in the rest of the survey. Interviewees also found language in the statements confusing or vague. For example, interviewees found the phrase "home institution" confusing, which appeared in many of the response options. Further, response options contained subjective terms, such as "valuable," or used terms such as "access" to a mentor rather than "had" a mentor. Further, interviewees commented throughout the survey that their STEM identity and self-efficacy was not as narrowly defined as the survey questions and response options. For example, interviewees reported having mentors who were not in STEM, but who contributed to their STEM self-efficacy. **Table 2** provides the original question and statements with the feedback from interviewees, and the initial suggested changes.

Interviewee comments about subjective terms, such as "valuable," led to team discussions about the purpose of the mentoring question. What did the research team really want to know: if they had mentors? Or who the mentors were and what they contributed to STEM identity and self-efficacy? Based on interviewee comments and our own discussion, the research team restructured the question on mentoring. The new structure more directly links mentors to STEM identity and self-efficacy.

The new question (**Table 3**) provides interviewees with a list of people and asks them to first indicate who has been a mentor for them, currently or in the past. The people include high school teacher, faculty member at my current undergraduate institution, family member or guardian, peer, and other general categories. The selected answers are then piped into a matrix question which asks interviewees to indicate their level of agreement with a series of statements about what they may have gained from these mentors. The statements are directly linked to sources of self-efficacy.

## "WHAT'S YOUR STEMSPIRATION?" FINALIZED SURVEY INSTRUMENT

Based upon the cognitive interviews and statistical analysis, the validated survey instrument was finalized. The questions were tailored to address each area of the conceptual framework (**Figure 2**). It is anticipated that this research will provide insight into the influence of STEM intervention programs as well as the experiences and opportunities they provide for STEM-career self-efficacy, research-related self-efficacy, academic-related self-efficacy, sources of self-efficacy, outcome expectations, and STEM identity within different institutional contexts.

A subset of questions was used to determine survey respondents' personal inputs, which are defined as those distal and proximal contextual factors that may have played a role in the students' choice of major or desire to pursue a STEM career. These "personal inputs" are unique lived experiences and cultural/social identities that influence choices, behaviors, norms, and expectations. These may be distal (e.g., family encouragement, middle school experiences, etc.) or more proximal (e.g., undergraduate extracurricular activities, cumulative GPA, etc.) in time. The survey also includes demographic information as personal inputs in this category, recognizing that students' social identities and cultural context may also provide contextual information (see examples in **Table 3**).

While personal inputs, mentors, participation in SIPs, and academic environments are all sources of self-efficacy in the domains of research, academic, and STEM careers, the "What's Your STEMspiration?" survey explores other factors that also influence self-efficacy. These include a sense of belonging at the respondent's institution and/or major, their confidence in their ability to remain in their major and complete their course work, and their own self-awareness. The survey explores these aspects as sources of self-efficacy with a series of questions, a subset of which are shown in **Table 3**.

As shown in **Figure 2**, the "What's Your STEMspiration?" survey is investigating self-efficacy across three domains: academic, research, and STEM career. These three areas were chosen based upon the responses from the UVA study, the cognitive interviews, and the types of intervention programs and opportunities offered by the VA-NC Alliance partners. For example, research experiences and research preparation are a core component of the VA-NC Alliance programs, thus it is important to investigate how participation in these programs correlate with research self-efficacy. Many VA-NC Alliance students participate in internships, externships, and/or cooperatives, thus this area was also deemed a focus area. Finally, fostering academic self-efficacy is a central tenet of the student educational experience and several SIP's (e.g., through peer mentoring, tutoring, supplemental instruction, study skills workshops, etc.). If students do not experience a mastery of certain skills needed for academic success in their respective majors, it could influence their retention in the major and expected outcomes. Sample questions which explore these areas are also provided in **Table 2**. Initially, mentoring was not included as a specific area of inquiry for this survey. However, based upon the responses during UVA's preliminary study, it was found that mentoring was a key component of the VA-NC Alliance student experience. Even though some models might include mentoring under sources of self-efficacy, SIPs, or personal inputs, this research revealed that it was significant enough to warrant its own uniquely identified factor in the model (**Table 3**).

As defined by Carol Couvillion Landry (2003), outcome expectancy is a "person's estimate that a certain behavior will produce a resulting outcome … Outcome expectation is thus a belief about the consequences of a behavior." In the domain of student outcome expectations, the research team members explore the future students envision for themselves after graduating with a STEM degree and how career or educational "next steps" align with their passions. The research team members also explore how prepared they feel to embark upon that career given the educational experiences (curricular, co-curricular, and extracurricular) in which they have been able to participate (**Table 3**).

The finalized survey instrument explores all aspects of the proposed model. The responses will provide data which will inform the focus groups' questions and interviews to be conducted in the next stage of this research.

## CONCLUSION

The research team plans to compare and contrast survey responses regarding student perceptions of the following: self-efficacy, research-related self-efficacy, academic-related self-efficacy, sources of self-efficacy, outcome expectations, and STEM identity in the context of their overall undergraduate institution(s) experiences, STEM disciplines, participation in SIPs, and aspirations for STEM graduate school and/or STEM careers. In order to identify disparities, the research team will also compare the responses of community college transfer, HBCU, and PWI students, as well as other groups within the Alliance (e.g., categorized by major, race, ethnicity, gender, among others). The validated survey instrument distribution began in February 2021. Data will be compared longitudinally and will inform the questions asked in student focus groups planned for the future.

Understanding that organizational cultures differ amongst Alliance institutions and that students possess intersecting identities, the research team anticipates finding a range of student experiences and program impacts specific to institutional contexts and personal inputs. This research project will assess the differentiated impacts and effectiveness of the Alliance's broadening participation efforts in order to improve program effectiveness. In addition, the research team will seek to identify emergent patterns, adding to the field of knowledge about culturally responsive SIPs. Results will be shared with the VA-NC Alliance partners, the Alliance's external evaluator, the National Science Foundation, and LSAMP programs across the country, among other stakeholders.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because The raw dataset is only available to the research team as specified in the IRB approval. Requests to access the datasets should be directed to rhobson@vcu.edu.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Virginia Commonwealth University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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# Increasing STEM Transfer Readiness Among Underrepresented Minoritized Two-Year College Students: Examining Course-Taking Patterns, Experiences, and Interventions

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There is a strong need in the United States to increase the size and diversity of the domestic workforce trained in science, technology, engineering, and math (STEM). With almost half of all students that earn a baccalaureate degree enrolling in a 2-year public college at some point, the nation's 2-year colleges provide great promise for improving the capacity of the STEM workforce for innovation and global competition while addressing the nation's need for more equity between groups that have been historically included and those that have been economically and politically disenfranchized. Almost half of underrepresented minoritized (URM) students begin their post-secondary education at 2-year colleges yet their transfer rates within 5 years are only 16%. This study describes interventions put in place at a 2-year college to support increased transfer rates and STEM transfer readiness for URM STEM-interested students. The program studied, in place from 2017 through 2020, had an overall transfer rate of 45%. Analysis of administrative, transcript, and student survey data connects the program interventions to the existing research on STEM momentum and other research on URM STEM transfer success. Ultimately, this study identifies potential leading indicators of transfer readiness, providing much needed documentation and guidance on the efficacy and limitations of interventions to improve upward STEM transfer.

**Keywords: STEM transfer, community college, diversify STEM science technology engineering mathematics, underrepresented minority, momentum, motivation, 2-year college, holistic support**



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## INTRODUCTION

The United States public interests including national defense, safety, health, computing, communication, and energy rely upon a domestic workforce that is highly trained in science, technology, engineering, and mathematics (STEM). Initiatives to increase the numbers of students who complete degrees in STEM must engage and retain students from racial and ethnic groups that have been historically excluded from full participation in higher education and actively discriminated against in the context of STEM education and research (Malone and Barabino, 2009; Benish, 2018; McGee, 2020). Interventions that support students' efforts to pursue a STEM career pathway while addressing institutional practices and policies that limit access to or complicate the navigation of such pathways hold the greatest promise for impact and sustainable change (Whittaker and Montgomery, 2012; Upshur et al., 2018; Wilson et al., 2018).

The transfer pathways between 2 and 4-year institutions play a critical role in growing a bigger and more diverse domestic STEM workforce (National Science Board, 2015). Collectively, community colleges have more students enrolled for degree credits than 4-year public and private institutions combined (Horn and Skomsvold, 2011; Handel and Williams, 2012). National Student Clearinghouse data show that almost half of students who have obtained their baccalaureate degrees had been enrolled in a 2-year public college during the previous ten years (Two-Year Contributions to Four-Year Completions, 2017). In 2010, Black and Hispanic students made up 23.3% of all students who began post-secondary education and almost half (49.6%) of those students started their college enrollment at a 2-year public college (Shapiro et al., 2017a). The Beginning Postsecondary Student Longitudinal Study (BPS) found that among first-time community college students, 80% of White students expressed an interest of earning at least a bachelor's degree with slightly larger percentages of Black (83%) and Hispanic (85%) students expressing such an interest (Horn and Skomsvold, 2011; Handel and Williams, 2012). Among community college students who are in STEM disciplines, 75% indicate they are enrolled to obtain credits toward STEM baccalaureate degrees (Mooney and Foley, 2011).

Transfer rates and degree completion rates are not consistent with the large percentages of students who intend to earn a bachelor's degree. On average, 26% of community college students transfer to a 4-year institution each year. For students who begin their post-secondary education at a 4-year institution, the degree completion rate is 70% for enrolled juniors. For transfer students, the six-year baccalaureate degree completion rate is 45% (Handel and Williams, 2012). When the scope of transfer success is narrowed to students majoring in science and engineering disciplines, the outcomes are even more concerning. An analysis of six-year outcomes for community college students found that 16% of science and engineering students and 7% of technician[1] students had completed a STEM baccalaureate degree (National Academies of Sciences, E., and Medicine, 2016). With respect to broadening participation in STEM, the factors that slow or complicate transfer and degree completion have a disproportionate impact on students from minoritized groups (Black, Latino/a, Native American, Alaskan Native, Native Hawaiian and other Pacific Islanders). One study found that the 2–4-year transfer rate after five years was 23% for White students compared to 16% for Black and Hispanic students (Horn and Skomsvold, 2011). With respect to degree completion, Black and Hispanic students starting at a 2-year college have bachelor's degree completion rates after six years of 8.6 and 10.8%, respectively, compared to 19.2% for White students (Shapiro et al., 2017a).

The discrepancy between student enrollments in community colleges with the intention to transfer and complete a degree in STEM and the transfer and degree completion rates for the same students indicates that the 2–4-year transfer pathways into STEM are not serving all students equally. The present study describes an intervention, the Madison College Inspire Scholars Program, to increase the STEM transfer readiness and ultimately transfer rates for underrepresented minoritized (URM) students[2] who are intending to pursue STEM careers. The program was based on an existing transfer preparation program at the college and on Wang's research (Wang, 2015a; 2015b) on supporting students with transfer aspirations in STEM.

## LITERATURE REVIEW

### Research and Evidence for Clear Pathways to Transfer Success

Wang's holistic theoretical model for community college student success specifies three domains within which momentum is developed: curricular (e.g., course-taking trajectories); motivational (e.g., students' aspirations and beliefs); and instructional (e.g., classroom and advising approaches that support students' engagement with learning a discipline) (Wang, 2017). Four key factors that stop or slow STEM transfer momentum are financial barriers, lack of clear pathways, inadequate or lack of advising, and lack of professional development for faculty, which she refers to as counter-momentum friction (Wang, 2017). Providing support and resources in each of these domains is key to supporting successful STEM transfer and baccalaureate degree attainment. The curricular and motivational momentum domains are the primary focus of this project.

Wang's momentum domains align well with other research on successful STEM transfer initiatives. For example, within the instructional domain, research shows the need to improve advising as a method to support student transfer in STEM (Carlsen and Gangeness, 2020; LaViolet and Wyner, 2020; Packard and Jeffers, 2013). Additional case studies have highlighted successful STEM transfer initiatives that address the motivational domain through holistic mentoring (Luedke, 2017; Rodenborg and Dessel, 2019) and development of a STEM identity (Rodriguez et al., 2017), and the curricular domain through strong transfer partnerships (Xu et al., 2018). In addition to addressing the counter-momentum friction that students experience, additional research has shown positive connections around supporting student momentum. The concept of "STEM Momentum" first defined by Wang (2015b), and based on prior work on academic momentum

[1]Technician in this context refers to occupational programs that award a certificate or applied associate degree.

[2]In this paper we use the term "underrepresented minoritized" (URM) to describe minority status based on disproportionate numbers of people from different ethnic and racial backgrounds. The term minoritized in this context reflects both the numeric underrepresentation as well as structural, social, and cultural factors that affect access to and persistence in STEM disciplines for students of color (Benitez, 2010; Stewart, 2013).

(Attewell et al., 2012), is the idea of studying both the quantity of STEM credits and the quality of progression in the STEM courses as leading indicators of successful STEM transfer. Wang focuses on the quantity and quality of students' progress through STEM coursework as a direct indicator of their momentum toward a likely, successful transfer. This is accomplished through analyzing a component of STEM momentum called STEM "Quality Points" a community college STEM-aspiring student earned in their first semester. STEM Quality Points (QP) represent the "velocity" component of STEM momentum and are calculated as the product of STEM course credits and associated course grade. For example, a B in a four-credit STEM transfer course equates to twelve STEM Quality Points. The number of STEM QP earned in a semester is an indicator of the speed that a student is working through their STEM coursework.

Wang's research on STEM momentum found that the predicted probability of baccalaureate attainment for a student starting at a community college was 11% compared to 46.6% for a comparable student beginning at a 4-year college. Wang found that increasing STEM QP in the first semester by one-point above the mean has a larger increase on the predicted probability of STEM success for 2-year college students than for students beginning at a 4-year college (5.5 vs. 2.8% increase). The importance of STEM momentum for STEM success reflects the social and economic factors that shape the pursuit of higher education for students who begin their studies at a 2-year institution compared to a 4-year institution. Students enrolling at 2-year institutions are more likely to have lower income, be first generation college students, and from groups that are minoritized in higher education, especially in STEM disciplines (National Center for Public Policy and Higher Education, 2011).

## Existing Barriers

Many interrelated factors impede students' transfer and degree attainment (Hagedorn et al., 2006; National Academies of Sciences, E., and Medicine, 2016; Wang et al., 2020). The financial burden of pursuing post-secondary education is one of the most significant barriers. Four-year institutions do not accommodate the working lives and income levels of their students to the same degree that community colleges do (Hill, 2017; National Academies of Sciences, E., and Medicine, 2016). On average community college tuition rates are much lower than tuition rates at 4-year institutions. In addition, community college students are more likely to work, and to work more hours per week, than their 4-year institution counterparts.

The financial burden of higher education is further complicated by the issue of how credits earned at a 2-year college are transferred into a 4-year institution. Credit transfers, especially for coursework in STEM majors which typically sequence courses, are not guaranteed even when institutions have articulation agreements. Transfer students report that they do not have sufficient advising to help them identify their options for STEM pathways and navigate the coursework to optimize time and resources spent on preparing for transfer into a STEM major at a 4-year institution. In addition, those pathways are often difficult to navigate and vary based on which 4-year institution the student plans to transfer to, further exacerbating the problem (Bailey, 2015; Handel and Williams, 2012; National Academies of Sciences, E., and Medicine, 2016; Wang, 2020; Wang et al., 2020).

One of the conditions necessary for transfer pathways to increase access and diversity in STEM include collaboration with transfer institutions. Access created by direct transfer agreements that specify course and credit equivalencies between institutions is a step in the right direction. Articulation agreements that guarantee "credits will transfer" do not shorten transfer students' time to degree if the credits from 2-year institutions are only counted as electives. Credits have to count toward required coursework within the major, especially because coursework in many STEM majors is sequenced (LaViolet and Wyner, 2020). An additional way to increase STEM success is to provide students opportunities to engage with high impact practices, especially the promising practice of undergraduate research. Research has demonstrated the positive impact on STEM success for students that engage with undergraduate research (Brownell and Swaner, 2009; Eddy, 2014; Kilgo et al., 2015), though there are barriers to access for community college students which can be partially overcome through utilizing REU's (Research Experiences for Undergraduates) that specifically target 2-year and URM students. There is also a need to better understand the two-year student population (Wickersham, 2020), especially the structural inequality and its impact on access and equity for underrepresented minoritized students (Bowleg, 2008).

# DESIGN OF INSPIRE SCHOLARS PROGRAM INTERVENTION

## Inspire Scholars Program Background

Madison Area Technical College (Madison College) is a comprehensive, public two-year college serving a district spanning twelve urban and rural counties in south central Wisconsin. Madison College provides a critical educational on-ramp to a baccalaureate degree especially for URM students. Our student population is diverse, with URM students making up more than 20% of our STEM associate degree students. Madison College has been a member of the 19-institution consortium that makes up the Wisconsin Louis Stokes Alliance for Minority Participation (WiscAMP) since 2012. The Madison College WiscAMP Scholars Transfer Preparation Program (WSTPP) builds upon direct transfer agreements created between Madison College and the UW-Madison College of Engineering, Milwaukee School of Engineering, UW-Milwaukee, and UW-Platteville. The WSTPP supports URM students whose academic profiles indicate they have STEM momentum and anticipate transferring into a 4-year STEM major within one year. The program facilitates students' transfer success by providing professional development, faculty mentoring, financial support through a stipend, and connecting them with programs and research opportunities at UW-Madison prior to transfer. Overall, 62% of WSTPP students transfer into a 4-year STEM major within a year of having participated in the program. Based on the success of the WSTPP, Madison College STEM faculty and administrators looked at how to extend the program's impact by expanding eligibility to the student supports in the WSTPP and expanding the supports available to help students build STEM momentum.

Though successful, the WSTPP has a number of limitations that the Inspire Scholars Program (ISP) was developed to address. One goal of the ISP was to "cast a wider net" through three key program eligibility changes to increase access to the program. The changes were based on research and direct experience with the WSTPP scholars. One limitation built into the design of the WSTPP is the eligibility requirements for students to participate. Since WSTPP was designed for students that were already well-established in their transfer path, it excludes the majority of STEM URM students that could benefit from the program. There are three eligibility requirements that create the largest barrier to the program. They are 1) the minimum math requirement of college algebra or higher (a.k.a. transfer-level math), 2) a minimum GPA of 2.8, and 3) the requirement that the scholars maintain full-time enrollment. For example, in the first semester of ISP implementation (Fall 2017), there were 3,310 students enrolled in STEM associate degree programs[3] with URM students totaling 820 (24.8%) of total enrollments. Of the 820 students, only 59 of the URM students were eligible for WSTPP.

Nationwide, data on student progression through mathematics demonstrates that there is a need for support for students in math below the level of college algebra. In Wang's research on STEM momentum (Wang, 2015b), the analysis was restricted to students that were in their first semester at the beginning of the study period that had started their math coursework at the level of college algebra or higher. However, the majority of students attending two-year colleges start their mathematics coursework at one or more levels below college algebra (Bailey, 2009). Remedial math courses are often seen as a "gatekeeper" to STEM success (Hagedorn and DuBray, 2010; Zhang, 2019). Only 12% of students that begin math at Madison College at the level of elementary algebra (two "levels" below) successfully progress to college algebra within three years, a rate that aligns with national figures. In addition, experience with scholars in WSTPP, led us to reflect on the need to provide more flexibility for scholars to participate in the program. This flexibility is achieved for ISP participants by reducing the enrollment requirement to half time or higher, and the minimum GPA to 2.25. These changes, along with the third change of reducing the minimum math level to elementary algebra, significantly increased our pool of eligible students. Out of the 820 enrolled URM students in fall 2017, more than half of them (463 students) were eligible to apply to the Inspire Scholars Program. This "wider net" allowed us to more broadly recruit for the program across the college community and increase awareness of the program with, not only students, but also advisors and faculty.

Wang's model for STEM momentum provided a framework for expanded supports for students in the ISP. Supporting students' curricular momentum was not explicitly included in the WSTTP design. Intentional development of supports to address curricular momentum came through understanding the critical importance of first semester STEM QP on student transfer success. A challenge and an opportunity for the program came in the background of the ISP participants. The majority of the participants were not in their first semester of post-secondary education and 2/3 of the participants started their math sequence below college algebra. The ISP was designed to both track and support STEM QP attainment each semester students were involved in the program.

A further innovation and expansion of supports for ISP is the design of tiered participation, modeled after the UW-Milwaukee WiscAMP STEM-Inspire program (https://uwm.edu/steminspire/program-overview/). This design provided multiple opportunities for students to engage in the program and allowed the students to maintain connection to the program and the student community throughout their time at Madison College. The different roles in the program are shown in **Figure 1**. As can be seen in the figure, when developing the model, the design was based on the idea of "vertical transfer". Vertical transfer is defined as a student's movement from a 2-year institution into a 4-year institution. Though there are some choices built into the design, in essence, the program was built for students to "enter" the program on the left as a Scholar Participant and then "advance" through the various roles until they successfully transferred in STEM.

## Inspire Scholars Program Implementation

In Fall 2017, Madison College opened the doors on its new STEM Center. The ISP leveraged the new space as its hub for the project. The space was the primary location for Inspire participants to gather, build community, and work together on STEM coursework either independently, through weekly participant "Study Jams" or with the help of an ISP peer tutor. In addition to utilizing the STEM Center, ISP also provided the supports listed in **Table 1**. The PI and Co-PI were funded to provide a release of 31 and 18%, respectively, for the first year of the program to develop and implement the infrastructure needed to administer the ISP. This release was reduced to 9 and 0%, respectively, during year 2 of the program. In the third year of the program, a project manager position within the STEM Center was created and filled. A significant portion of the administrative duties associated with the ISP were transitioned to the project manager. Therefore, no funding for release time was provided to either the PI or Co-PI during the third year. Seventeen full time faculty applied their service hours as faculty mentors. Funding was provided for six part time faculty to also serve as mentors to participants. Faculty mentors were required to meet with their mentees for at least 2 h/mo and encouraged to attend the bi-weekly meetings (2 h/mo). The Co-PI developed and conducted training workshops and provided a handbook for all faculty mentors. Each semester, up to 35 students could be supported by the program in the roles shown in **Figure 1**. As many as four

[3]Madison College STEM associate Degree programs are provided in the Supplementary Materials.

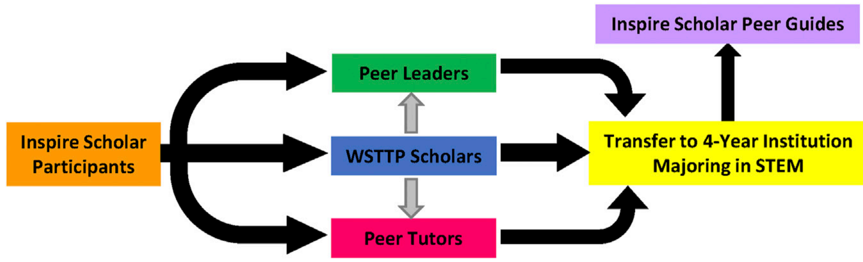


**FIGURE 1 |** Tiered participation model in the Madison College LSAMP Inspire Scholars Program.

**TABLE 1 |** Student supports provided in the Madison College Inspire Scholars Program.

| | |
|---|---|
| 1 | Provide stipends tied to the participant commitment and level of involvement |
| 2 | Expand recruiting strategies to include classroom visits, collaborating with institutional research to improve targeting and with the madison college recruitment office to coordinate with other STEM-related student outreach efforts |
| 3 | Implement faculty mentor training through a college-wide mentor-training initiative that included a mentoring handbook to support holistic mentoring |
| 4 | Coordinate career exploration workshops, additional student research opportunities and industry tours through collaboration with the madison college career and employment center |
| 5 | Develop leadership skills through professional development for peer leaders, guides and tutors |
| 6 | Support participant science identity through required participation in STEM outreach activities to K-12 and community partners |
| 7 | Provide academic and career professional development in biweekly meetings and engagement with the STEM Center's "STEM speaker" series |
| 8 | Provide academic and social support to scholars through peer tutoring and biweekly study sessions |
| 9 | Provide faculty mentoring for participants from trained STEM faculty |
| 10 | Provide a "bridge" to transfer with UW-Madison through a transfer collaboration effort with UW-Madison WISCIENCE and a team of student ambassadors from UW-Madison |

students served as peer tutors and three students served as peer leaders. Peer tutors worked up to 14 h/wk per semester and peer leaders worked up to 12 h/wk per semester. Funding of $100 per academic year was also provided for up to three peer guides. Funding provided for up to 25 participants to receive a maximum stipend of $500 per semester. Stipends were adjusted relative to participant commitment and involvement in the program. The PI developed and implemented a training program/and or coordinated the activities of the peer tutors, peer leaders, and peer guides.

Each of the program components supports students' aspirations for transfer in specific ways. Access to transfer services is key for supporting STEM student momentum for transfer (Wang et al., 2017a). ISP participants received this support through presentations during the ISP participant biweekly meetings, targeted text messaging or "nudging" (Bird et al., 2021; Castleman & Page, 2015) to attend transfer fairs and scheduled transfer advising sessions, and engaging with faculty mentors. The research shows a strong correlation between successfully transferring in STEM and a STEM-interested student's identity as a STEM learner (Carlone and Johnson, 2007; García and McNaughtan, 2020; Rodriguez et al., 2017; Wang, 2020; Wang et al., 2020). Supporting ISP participants' STEM identity was done through holistic faculty mentoring, career presentations led by STEM professionals of color, and engaging the peer guides (participants that had already successfully transferred into STEM) to work with the participants. Requiring participants to develop and staff STEM outreach activities also allowed them to strengthen their STEM identity (Atkins et al., 2020). Another support for students was in the curricular momentum domain in the form of opportunities for tutoring and academic support from peers utilizing the peer tutors in the ISP and regular, required group study sessions (study jams) held in the STEM Center. (Jackson et al., 2013; McPhail, 2015). These opportunities were built to support not only curricular momentum, but also support community building and the participants' STEM identity. How students are advised and mentored regarding which classes to take, the sequence of classes, and the numbers of classes is also critical as these interventions all support STEM QP attainment (an indicator of curricular momentum). As such, the program provided professional development for faculty mentors and presentations to advisors on the importance of STEM QP and how advising and mentoring could best support students in this domain.

Further research into student success emphasizes the need to focus on "non-cognitive" factors (Farrington et al., 2012) including motivational attributes to support students' upward STEM transfer aspirations. One of the critical ways to support student motivation is through regular mentoring (Dowd, 2012; Packard, 2012). ISP provided mentoring through biweekly meetings with faculty mentors, leadership with peer leaders, and support to apply for and participate in summer REU's.

An additional support mechanism came in the form of the ISP student community. Building community among the scholars has been shown, through programs such as the Meyerhoff Scholarship Program at the University of Maryland Baltimore County, and the PEERS program at UCLA to have a strong positive impact on URM student STEM success (Maton and Hrabowski, 2004; Stolle-McAllister et al., 2011; Toven-Lindsey et al., 2015). By providing the varied roles in the program, the ISP was able to accept 69 students into the program over the course of the three years. The maximum number of students recruited in a single semester for the program was 33, which occurred in the first semester. Overall, the average number of students per semester in the program was 25.5. Participants were required to attend biweekly meetings for academic and career professional development, and for community building. The peer leaders were also tasked with supporting community through organizing volunteer activities and reaching out to participants that were unresponsive to faculty mentors.

## Inspire Scholars Program Eligibility and Recruiting

The eligibility requirements for the program varied based on the role of the participant. As shown in **Figure 1**, there were four possible roles for ISP participants. Each tier of student participation had unique requirements for the students, though all tiers required students to be classified as URM students interested in STEM transfer who are either United States citizens or permanent residents. Each student role was recruited based on the additional criteria outlined below.

- Inspire Scholars Participant–Qualifying students are URM students with an interest in a STEM career that are:
  - o Applicants to the WiscAMP Scholars Transfer Preparation Program that were not selected OR
  - o Part-time (min six credits) or more STEM-interested URM students that
    - Have a 2.25 minimum GPA.
    - Complete the LSAMP Inspire Scholars Participant Application.
- Inspire Scholars Peer Tutors–Qualifying students are:
  - o URM students that have taken STEM coursework and earned an A or AB in the course.
- Inspire Scholars Peer Leaders–Qualifying students are:
  - o URM students that have participated in the Inspire Scholars Program or WiscAMP Scholars Transfer Preparation Program that wish to gain leadership skills through the peer leaders program.
- Inspire Scholars Peer Guides–Qualifying students are:
  - o URM students that have participated in the Inspire Scholars Program or WiscAMP Scholars Transfer Preparation Program that have successfully transferred in STEM.

Recruiting for the program took on a "multipronged" approach. Because of the opening of the new STEM Center, a key aspect for the recruiting effort was to utilize the new STEM Center to let the broader college community know about the program and utilize the Center as a hub for collecting applications and fielding inquiries about the program. In its first semester, STEM faculty visited 84 STEM classrooms on behalf of the STEM center to promote the program and encourage students to apply. Utilizing student data gathered from the Institutional Research office, email contact information for all underrepresented eligible students at the college was used to send out targeted recruiting emails. Undeclared students were included in this group, leading to emails sent to 1,454 students. Additionally, because of the tiered participation model, former WSTTP applicants and participants still on campus were contacted and encouraged to apply to the program. Another targeted effort came from emailing faculty that teach the developmental math courses (elementary and intermediate algebra) with a list of the URM students in their classes and requesting that they personally invite their students to apply. An effort was also made to work with other programs at the college including TRiO, Scholars of Promise, and the Scholars of Color Mentoring Program. The ISP application was provided to personnel in those programs to pass on to any STEM-interested URM students in their program(s). Finally, STEM faculty staffed a recruiting table during new student orientation to identify eligible students and encourage them personally to apply.

During the three years of the ISP, 115 students submitted a completed application, and 69 students were accepted into the program. The students who were denied participation in the program generally fell into two groups. Most were not members of the minoritized groups eligible to participate in the program as defined by the National Science Foundation. The second group of students who were denied participation did not show any evidence that the option of transferring to a four-year institution was being given serious consideration. Students' lack of intention to transfer was demonstrated by the absence of any transferable STEM courses in their academic record and/or by explicit statements provided in the application.

# EVALUATION

The Inspire Scholars Program had the overarching goal of broadening participation in STEM degree career pathways. It was developed to augment the successful Madison College WSTTP by providing broader and more diverse entry points into some of the proven programming and supports already in place for the WiscAMP Scholars. The program had three specific objectives.

- o Objective #1: Increase the STEM transfer readiness of all Inspire Scholars Program participants.
- o Objective #2: Increase the number of URM students that successfully transition from remedial math coursework into the STEM transfer track.
- o Objective #3: Increase the number of URM Madison College students who transfer into STEM programs at the college's top STEM transfer institutions.

Assessment of the program draws from transcript data (to track accumulation of students' STEM quality points and transfer success) as well as surveys administered to students when they began and exited the program. The survey instrument was modified from the upward transfer survey instrument developed by Wang (Wang, 2016; Wang and Lee, 2019).

## Key Indicators of Program Success

The focus of this study is on Objective 1. The program definition of STEM transfer readiness is based on the work around STEM Momentum advanced by Wang (Wang, 2015b, 2017; Wang, 2020). Transfer readiness includes both curricular momentum (operationalized as STEM Quality Points) and aspirational momentum (operationalized through multiple scales assessing key attitudes and beliefs as outlined below). The survey questions and categories as described below were modified from Wang's upward transfer survey instrument (Wang and Lee, 2019). The complete set of matched questions used in the analysis in each category is available in the supplementary materials.

### STEM Quality Points

Transcript data was used to track participants' STEM Quality Points attained per semester which are calculated as a function of math and science course credits multiplied by the grades earned for the course. For example, a student who completed a four-credit math course with a 3.0 earned 12 quality points.

### Math Self-Efficacy

Completion of transfer-level math is often used by programs (including the WSTPP) as a benchmark for identifying students who are likely to transfer successfully into STEM. The aim of ISP was to expand access to transfer preparation opportunities and include students who were not yet ready to enroll in transfer-level math. The program activities aimed to support the development of math self-efficacy to support students' continued coursework in math and science. Math self-efficacy was assessed by responses to five questions (e.g., "How confident are you that you can do well on math exams?") on Likert scale items (1 = "not at all" to 5 = "extremely"). Wang and Lee (2019) have documented a Chronbach's alpha for this measure of 0.95. The scale reliability analysis of the measure for this sample resulted in alphas of 0.93 and 0.95, for the baseline and first follow-up surveys, respectively.

### Science Self-Efficacy

Students' confidence that they can master content with a science discipline was assessed by responses to five questions (e.g., "How confident are you that you have the ability to master the material taught in science?") on Likert scale items (1 = "not at all" to 5 = "extremely"). Wang and Lee (2019) have documented a Chronbach's alpha for this measure of 0.96. A scale reliability analysis of the measure for this study resulted in alphas of 0.95 and 0.96, for the baseline and first follow-up surveys, respectively.

### Support for Transfer

Wang's holistic model of STEM momentum considers the supportive factors that contribute to students' persistence in navigating the STEM transfer pathway. Students' levels of support for transfer were assessed with responses to four questions, two regarding support from family and friends and two regarding financial support for the current and future academic goals on Likert scale items (1 = "none" to 5 = "a great deal"). Wang assessed the four items used for this scale in a confirmatory factor analysis (see Wang and Lee, 2016). The scale reliability analysis of the measure for the present study resulted in alphas of 0.67 and 0.59 for the baseline and first follow-up surveys, respectively.

### Transfer Information Acquisition

Students' lack of information about the transfer process and options for navigating the STEM transfer pathway can result in costly decisions in terms of time, money, and academic performance. Students' transfer information acquisition was assessed with five Likert responses to questions regarding how familiar students were (1 = "not at all" to 5 = "extremely") about different resources for guiding their transfer process. Wang assessed the five items used for this scale in a confirmatory factor analysis (see Wang and Lee, 2016). The scale reliability analysis of the measure for the present study resulted in alphas of 0.89 and 0.93 for the baseline and first follow-up surveys, respectively.

### Transfer Capital

Students' connections to places and people who can help them navigate the transfer pathway were assessed with responses to five questions regarding actual behavior and intentions (e.g., "Have you met with a transfer advisor from a 4-year college or university?"). Responses were scaled 0 to two based on three response categories: 0 = "No, and I don't intend to;" 1 = "No, but I do intend to;" and 2 = "Yes"). The measure of transfer capital is changed from Wang and Lee (2016) survey which used confirmatory factor analysis to assess a five-point Likert scale measuring Transfer-Oriented Interactions with 1 = "Never" to 5 = "Very often." For the evaluation of the ISP, participants were asked to report on their actions with respect to five activities that directly support transfer. The scale reliability analysis for this adapted scale resulted in alphas of 0.60 and 0.65 for the baseline and first follow-up surveys, respectively.

### Transfer Self-Efficacy

One specific question was used to assess students' transfer self-efficacy: "How confident are you about your ability to handle the process and requirements for transferring to a four-year college or university?" with responses in the form of a Likert rating (1 = "not at all" to 5 = "extremely").

## Evaluation Outcomes

A total of 69 students participated in the Madison College Inspire Scholars Program from 2017 to 2020. **Table 2** provides the demographic information for program participants and **Table 3** provides information about the participants' academic pathway. The average age for all participants in their first term with the program was 23.3 years old with a median age of 20, with Black students making up the majority of 24 and older students.

**TABLE 2 |** Inspire Scholars Program participant demographic information in their first term in the program.

| | | *N* (=69) | %[a] |
|---|---|---|---|
| Gender | Male | 35 | 51 |
| | Female | 34 | 49 |
| Age at first semester of program participation | 17–19 | 31 | 45 |
| | 20–23 | 17 | 25 |
| | 24–29 | 8 | 12 |
| | 30 and older | 13 | 19 |
| Race/Ethnicity | Black | 30 | 43 |
| | Hispanic | 31 | 45 |
| | Multiracial | 5 | 7 |
| | Native American | 3 | 4 |

[a]*Percentages may not total 100 due to rounding.*

**TABLE 3 |** Inspire Scholars Program participant academic plan in their first term in the program.

| Academic plan | Number of students |
|---|---|
| Civil engineering technology | 2 |
| Electrical engineering technol | 2 |
| Information technology | 5 |
| Liberal arts transfer–Arts | 8 |
| Liberal arts transfer–Engineering | 7 |
| Liberal arts transfer–Science | 42 |
| Mechanical design technology | 1 |
| Medical laboratory technician | 1 |
| Undeclared degree credit | 1 |
| Grand total | **69** |

These ages are in line with the entire population of eligible students during the semesters the program was running, where the average age of all eligible students was 23.7 years old with a median age of 21. Based on survey responses, 61% of the participants were first generation college students. Since surveys were limited to participating students, it is not feasible to develop a comparison group to broaden the impact of this study. Specifically, one issue that arises is the difficulty comparing first generation status and economic standing with other students across the college due to the fact that the college only recently started collecting this data from all students, and many students choose not to report those items to the college. For example, only 4% of the participants did not report status for first generation in the program survey, whereas 35% of the participants and 33% of eligible students did not report that information to the college.

## Transfer Readiness Analysis

As stated in objective 1 for the project, the STEM Quality Point attainment of the scholars is one of the factors used to identify "transfer readiness". In Wang's analysis on STEM momentum, transfer results were looked at within 6 years of the student's first term. The student cohort was limited to students in their first semester in 2003–2004, aged 23 or younger, majoring in a STEM field when first enrolled, and had taken at least one transfer-level STEM course during their first year. In addition, remedial math courses were excluded from the STEM momentum measures, and STEM programs were limited to those available at both a 2-year and a 4-year institution (Wang, 2015b). The population of students that participated in the ISP does not align easily with the cohort utilized by Wang for calculating STEM QP. This is a direct result of the tiered participation model and the decision to allow students entry into the program at math course-taking levels below college algebra. In fact, only six of the 69 scholars meet the cohort limitations from Wang's study. Even so, the evaluation of participants' transfer readiness was an opportunity to calculate STEM QP for the broader population in the ISP and make some preliminary findings on how well STEM QP correlates with STEM success for students outside the limited cohort previously studied. To assess the STEM Quality Points of the ISP participants, it was therefore necessary to develop a set of assumptions that aligned with and expanded those set by Wang. The set of assumptions used to analyze the STEM QP for the ISP were developed by looking at Wang's assumptions and making appropriate adjustments. First, since the program was in place starting in Fall 2017, the maximum number of years for this study is limited to at most 3 years since program start (instead of the 6 years used by Wang). In addition, due to the design of the program, only eleven of the 69 participants were in their first term (16%), and 48 participants were 23 years old or younger (70%) in their first term as a participant, it was therefore decided to not limit the cohort to students in their first term. Since the ISP cohort also included students with transfer credit, the STEM QP analysis excluded participants with 16 or more credits transferred in from another college. 16 credits was chosen based on 15 credits representing one semester for a "full-time equivalent" student which ensures that the majority of the student's coursework was completed at Madison College. This limitation excluded five scholars with 16–45 credits of transfer coursework. In addition, because this study is focused on STEM Quality Points, scholars that successfully completed transfer-level math or other STEM coursework at another institution were also excluded from the STEM QP analysis (2 additional scholars excluded). This study also deviates from Wang's analysis in that it has no age limit and does not look at STEM coursework to determine STEM intent since eligibility for the program required all students to have a stated interest in transferring into STEM and an expectation to earn a bachelor's degree or higher. To maintain alignment to Wang's analysis, the STEM QP calculations in this study were limited to the students in the Liberal Arts Transfer program, since much of the course work students completed in the other programs was not "readily transferrable" to a 4-year college. Finally, since Wang's STEM momentum analysis focused on the first semester a student took coursework, and fully 2/3 of the program participants took at least one remedial math class at the college, "first semester" for STEM QP calculation was defined for this program as the (non-summer) semester where the student first attempted transfer-level math. Five of the scholars never attempted transfer-level math and thus were also excluded from the STEM QP analysis. These limitations ultimately produced a cohort to study STEM QP of 47 students (68% of the ISP participants).

The STEM QP students attained was calculated for the 47 students during each semester they participated in the ISP. Of the 47 students, 19 of them attained their "first semester STEM QP" before the program and 22 students attained them during their time in the program. The median number of first semester STEM QP between the two groups was 15 (before) and 19.5 (during). Recall that STEM QP is a focus of this study because higher first semester STEM QP attainment is associated with higher probability of STEM transfer success. So, how did these students fair regarding transfer? Fifteen of the nineteen students that completed their first semester STEM QP before the program successfully transferred with a median STEM QP for this subgroup of 20. Of the 22 students that earned their first semester STEM QP during the program, 11 have successfully transferred and/or earned an associate degree with a median QP of 27. It is worth noting that, although fewer students have transferred that completed their first semester STEM QP during the program, those students were, on average, not as far along in their transfer journey as those students that had already completed transfer level math prior to starting the program.

Overall, the mean first semester STEM QP for all 47 participants was 15.8 with a standard deviation of 12.3. Participants were much more likely to have successfully transferred and/or earned an associate degree if they earned first semester STEM QP above the mean.

- 10 out of 24 transferred (42%) that earned STEM QP below the mean vs.
- 18 out of 23 transferred and/or earned an associate degree (78%) that earned STEM QP above the mean.

To assess how program participation might influence participants' attitudes and behaviors relevant to STEM transfer, scholars were required to complete a baseline survey upon entrance into the program, and a follow-up survey at the end of each semester they participated. Sixty-four of the 69 participants (93%) completed the baseline survey, and 48 of the 69 participants completed the follow-up survey at least once (70%). A total of 45 scholars completed both a baseline and at least one follow-up survey. For participants that completed either survey more than once, the first submission of each survey was utilized for analysis. Although this restriction limits the amount of time between the baseline and the follow-up assessment, it reduces the likelihood that participants' responses will be influenced by responding to the same survey questions multiple times.

Comparison of participants' baseline and follow-up reports of their intent to transfer in STEM, shows no significant change. It is important to note that a program eligibility requirement was a stated intent to transfer in STEM, so the mean response to the survey question "*How likely are you to transfer to a four-year college or university to study in a program within science, technology, engineering, and mathematics (STEM) fields of study?*" was 4.4 in the baseline survey, and 4.5 in the follow-up survey (out of a 5-point Likert scale). The survey responses were combined into the scales previously described: Math Self-Efficacy, Science Self-Efficacy, Support for Transfer, Transfer Information Acquisition, and Transfer Capital. A sixth measure, Transfer Self-Efficacy, was measured with a single item. The means for each scale were calculated for the baseline survey responses and for the first completed follow-up survey.

**Table 4** summarizes the paired *t*-test analyses used to gage the program impact on six cognitive and behavioral indicators of ISP participants' STEM momentum. Four of the six measures show significant increases with the largest effect sizes found for changes in transfer information acquisition and transfer capital (1.08 and 1.01, respectively). Recall that the measure of transfer capital assesses participants intention as well as actual completion of five activities that are related to developing transfer capital. Responses to each of the five questions about transfer capital activities (e.g., Have you met with a faculty member at a 4-year institution?) range from 0 "No, and I don't intend to do so," 1 "No, but I intend to do so," and 2 "yes." The pre- and post-means are both greater than 1, the maximum score that could be achieved with only "intentional" responses, thus indicating that participants have completed or intend to complete at least some of transfer capital activities.

## Transfer Pathway Progress

Thirty-One of the participants (45%) have successfully transferred since the program began in Fall 2017, with thirty of the participants transferring in a STEM major. This transfer rate is more than twice the 21% baseline transfer rate of URM STEM transfer students from Madison College for the Fall 2017 cohort. In addition, half of the program participants that transferred also graduated from Madison College with an associate degree along with an additional eleven participants, resulting in a total of 42 out of the 69 participants successfully earning an associate degree and/or transferring (61%). **Table 5** shows the transfer pathway progress based on gender as well as race/ethnicity. Women were more likely to have transferred than men (53% and 37%, respectively). Multiracial, Native American, and Hispanic students were more likely to stop out than Black students.

The program was also designed to support students that were traditionally ineligible for the WSTTP, including those students that are at the beginning of their college career or are taking remedial math coursework. Research by Bahr (Bahr, 2010) on students' experiences with remedial math, found that Black and

**TABLE 4 |** Summary of paired *T*-Tests for transfer readiness analysis.

| | Mean | | St. Dev | | T | Df | Sig. (1-Tailed) | Effect size (Cohen's D) |
|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | | | | |
| Math self-efficacy | 3.99 | 4.09 | 0.792 | 0.812 | 0.909 | 44 | 0.185 | 0.72 |
| Science self-efficacy | 4.06 | 4.04 | 0.748 | 0.741 | 0.168 | 44 | 0.434 | 0.70 |
| Support for transfer | 3.02 | 3.39 | 0.933 | 0.867 | 3.940 | 44 | 0.000 | 0.64 |
| **Transfer info. Acquisition** | 2.70 | 3.26 | 1.022 | 1.095 | 3.452 | 44 | 0.000 | **1.08** |
| Transfer capital | 1.34 | 1.48 | 0.396 | 0.407 | 2.584 | 44 | 0.007 | 0.37 |
| **Transfer self efficacy** | 3.60 | 3.87 | 0.837 | 0.842 | 1.773 | 44 | 0.042 | **1.01** |

[a]*These scales are to assess the effectiveness of the program interventions around improving participant self-efficacy in STEM transfer and navigating the college system.*

**TABLE 5 |** Transfer pathway progress by gender and race/ethnicity for ISP participants (*N* = 69).

| | | Transferred[a] | | Earned associate degree | | Enrolled | | Stopped-out | |
|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | N | % |
| Gender | Female | 18 | 53 | 2 | 6 | 5 | 15 | 9 | 26 |
| | Male | 13 | 37 | 9 | 26 | 9 | 26 | 4 | 11 |
| Race/Ethnicity | Black | 13 | 43 | 7 | 23 | 7 | 23 | 3 | 10 |
| | Hispanic | 15 | 48 | 4 | 13 | 5 | 16 | 7 | 23 |
| | Multiracial and Native American | 3 | 37.5 | – | – | 2 | 25 | 3 | 37.5 |
| Total | | 31 | 45 | 11 | 16 | 14 | 20 | 13 | 19 |

[a]*Transferred includes students that transferred and also earned an associate degree.*

Hispanic students are more likely to enter college needing at least one remedial math course than their White and Asian counterparts. They are also less likely to advance and achieve a passing grade in a transfer-level math class than their White and Asian counterparts. In Bahr's study, one in nine Black students that placed into remedial math eventually succeeded at completing a transfer-level math course, and one in five Hispanic students were successful, compared to one in four white students and one in three Asian students. Of the Inspire Program participants, 46 of the 69 participants took remedial math at Madison College, with 25 of the participants (36%) taking remedial math in their first semester as an ISP participant. Of the 25 students, 10 have transferred or earned an associate degree (40%), and an additional seven students are still enrolled. Overall, the 46 participants that experienced some math remediation have a transfer and associate degree completion rate of 56.5%, compared to 69.6% for the participants that never remediated in math.

## DISCUSSION

Two-year institutions are important access points for students who want to pursue STEM careers, especially students from communities that are minoritized in STEM disciplines. The focus of this work is to describe a successful program at a 2-year college that was designed to support underrepresented minoritized (URM) students transferring from the two-year college into a four-year STEM major at a four-year institution. We are seeking an increase in STEM transfer readiness through STEM Quality Point attainment, better self-efficacy in STEM transfer and navigating the college system, and a greater commitment to STEM transfer and career goals. Though challenging to implement in practice, preliminary results from this study suggest that supporting students in the curricular domain to take more STEM credits and to successfully complete those credits early in their academic career (analyzed as first semester STEM Quality Points) improves their probability of successfully transferring. Most striking, this result held true for students even if they are starting their math trajectory below college level. The median STEM QP attained by students that successfully transferred and that completed their first semester STEM QP during their time with the program was also substantially higher than for the students that transferred and completed their first semester STEM QP prior to participating in the program. These promising results speak to the efforts put in place to support students in the curricular domain, although further research with a comparison group is needed to establish the independent impact of the program on participants' academic progress and success. The program supports included providing professional development to faculty mentors and academic advisors on the importance of STEM Quality Points, and through providing peer tutoring and weekly "study jams" for participants to support their success in STEM coursework. Additional support for participants, especially those at the remedial math level, was found through interactions with peer

**TABLE 6 |** Inspire Scholars Program participant momentum trajectories by academic load.

| Academic load | Linear upward | Detoured | Deferred | Taking a break |
|---|---|---|---|---|
| Half-time | 2 | | 2 | |
| Three-quarter time | 2 | 3 | | 4 |
| Full time | 28 | 14 | 5 | 9 |
| Total | 32 | 17 | 7 | 13 |
| % Of total (out of 69) | 46% | 25% | 10% | 19% |

leaders, regular ISP meetings, and utilizing the STEM Center for additional community building and peer support.

The process of developing the cohort and a definition of "first semester" to use for analysis of STEM Quality Points brought sharply into focus how few of the participants in ISP 'fit' the traditional "vertical transfer" model. Wang and other researchers have broadened the STEM Momentum model (Park et al., 2020; Wang, 2017) to include student aspirations and motivation as predictors of STEM Baccalaureate success. This more nuanced look at the student experience is further investigated in Wang's book "On My Own" (Wang, 2020) which categorizes the STEM student transfer experience into four "momentum trajectories". The first trajectory, called "Linear Upward" follows the vertical transfer model that is the typical model for transfer from a 2 to 4-year institution and is used in much of the research around transfer (Handel, 2013; Handel and Williams, 2012; Shapiro et al., 2017a; Shapiro et al., 2017b). The second trajectory is referred to as "detoured". This detoured group experiences delays in transfer and/or engages in "swirling", which, in itself, has many definitions (Wang and Pilarzyk, 2009; Soler, 2020; Wickersham, 2020), though, most generally is defined as back-and-forth enrollment at different institutions. The third trajectory is the "deferred" student, which is a student that chooses to forego transfer after credential completion at the two-year college. The final trajectory, called "taking a break" is the students that are typically categorized as "stopped-out", though, as noted by the student interviews in the book, that does not necessarily mean they will not return to their studies at a later time (Adelman, 2006; Shapiro et al., 2017a). Each of these trajectories points to the varied ways 2-year college students navigate their journey to transfer and highlight the challenges researchers face to understand the *how* and the *why* of successful STEM transfer. The participant characteristics were matched onto the momentum trajectories defined in Wang (2020, pp. 193–194), leading to the breakdown for all 69 participants in the program as shown in **Table 6**. As can be seen in the table, fewer than half of the participants were "Linear Upward" in their trajectories.

Often, programming to support STEM transfer is designed for the "linear upward" group of students, though results from this program (see **Table 7**) show just 25 of the 42 students (60%) that transferred and/or earned an associate degree were in the Linear Upward trajectory. The large number of students in the "Detoured" momentum group were found to have either spent a large number of semesters at Madison College, or have transfer credits from one or more other colleges, and/or repeated critical STEM coursework.

Breaking down the participant characteristics by momentum trajectory allows for some interesting patterns to emerge and highlights some unintended challenges and benefits of the Inspire Scholars Program. For example, it is not surprising that all of the "deferred" students came from applied associate degree programs. Students in those programs do have access to transfer, but in general, the transfer agreements in place for their programs are in place for only a specific college, that is often expensive, or has other barriers such as being outside of the local area. So, the students end up with credits with very limited transferability. In addition, almost half of the Black, male scholars were on this trajectory and enrolled in applied STEM programs, which explains why the transfer rate for women was higher than for men as shown in **Table 5**. Another interesting finding is the large number of 'detoured' students that the program was able to support to successfully transfer and/or earn an associate degree (10 out of 17 students or 59%), with the remaining students still enrolled at Madison College. Another promising result from ISP is the large percentage of the students in the Linear Upward trajectory that are low income, as shown in **Figure 2** and 1st generation, as shown in **Figure 3**.

There are limitations to the conclusions that can be drawn from this study, due to the small number of participant ($n = 69$), and the challenges that exist in having participants engage with the program and differing points in their journey, and the diverse student trajectories. That said, the promising results from the Madison College Inspire Scholars Program show that interventions *can* help support URM STEM-interested students build transfer capital in the following ways:

- By providing a variety of roles for participants to engage with the program, students were able to create and grow with a STEM community and engage with the program at a level that worked best for their personal and educational needs. 20% of the participants held more than one role while engaged with the ISP, and 36% of the participants were involved with the program for at least three semesters.
- The academic and professional development provided to participants during the biweekly meetings and engagement with faculty mentors ensured participants had support to help navigate the confusing path to transfer. The meetings were run by peer leaders with guest speakers and topics during the meetings including: choosing a transfer institution, financial literacy and paying for college, applying for REU's, creating a professional presence, and more. In addition, faculty mentors were provided with checklists with key transfer and enrollment-related deadlines to support participants during their one-on-one meetings.
- The partnership with UW Madison created connections with students, faculty, staff and administrators at the college's top

**TABLE 7 |** Transfer and associate degree completion status of Inspire Scholars Program participants by momentum trajectory.

| Trajectory | Status | # Of students |
|---|---|---|
| Linear upward | Transferred[a] | 24 |
| | Earned an associate degree | 1 |
| | Enrolled | 7 |
| Detoured | Transferred[a] | 7 |
| | Earned an associate degree | 3 |
| | Enrolled | 7 |
| Deferred | Earned an associate degree | 7 |
| Taking a break | Stopped out | 13 |
| Total | | **69** |

[a]Transferred includes students that transferred and also earned an associate degree.

transfer institution. Students and staff from UW Madison attended a program meeting each semester at Madison College to answer transfer questions and support community building. This was followed by a transfer event hosted by UW Madison that participants attended where they heard from former participants that successfully transferred, faculty, administrators, and other students about the transfer process. All of this culminated in a STEM Immersion 4-day transfer experience for all participants that were accepted to UW Madison to ensure a smooth transition.

The WSTPP gave "proof of concept" for much of the programming and supports implemented in the ISP. Specifically, the ISP built on the faculty mentoring, regular participant meetings, student stipends, and partnerships with transfer institutions. In addition, the WSTPP created a base of faculty mentors and students that increased awareness of the program and provided an initial pool of peer tutors and peer leaders from which the ISP could recruit. Processes developed in the WSTPP were expanded and institutionalized in the ISP so that students who did not satisfy WSTTP application requirements were able to access the programming through the ISP. The supports of the STEM Center, the UW Madison STEM Immersion, the one-to-one course transfer into a number of STEM programs across the state, and the geographic availability of UW Madison, all worked to support this project. Overall, the interventions and supports implemented for this program worked in tandem to provide support and improve the success for student participants.

## Suggestions for Future Work

The strong results from the program have limitations that could be addressed in future work. As discussed earlier, the lack of a clear comparison group prevents robust experimental analysis of the program. A method of limiting the cohort to first semester, first time students does not adequately capture the aspects of the eligible students for this project. The authors suggest surveying all eligible students at the beginning and end of a semester. Connecting the survey data with transcript and administrative data would enable a thorough analysis of the program to determine cause and effect. Interviewing students that participated in the program would also provide valuable insights into the student experience.

In addition to a more robust analysis, there are areas to expand the program that show promise to benefit students intending to transfer in STEM, one being the development of new and/or stronger partnerships between 2 and 4-year institutions. These partnerships would provide opportunities for faculty to cultivate relationships across institutions, which have been shown to benefit transfer students (Martinez, 2019). These relationships are also critical to enable applied associate degree programs and 4-year transfer partners to build more robust/broadly accepted transfer agreements and coursework. Finally, a component of holistic momentum that was left untouched by the design of this program is in the instructional domain, specifically the student experience in the classroom. Efforts to support faculty to improve

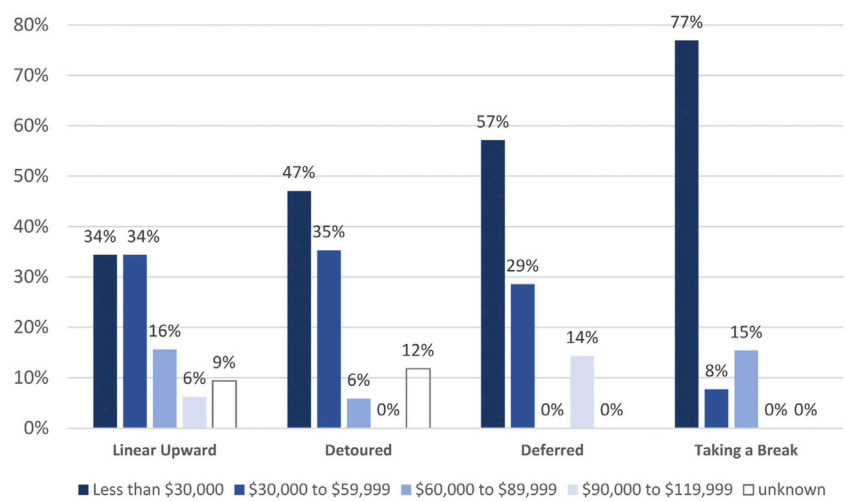


**FIGURE 2 |** Percentage of program participants on the four momentum trajectories by family income.

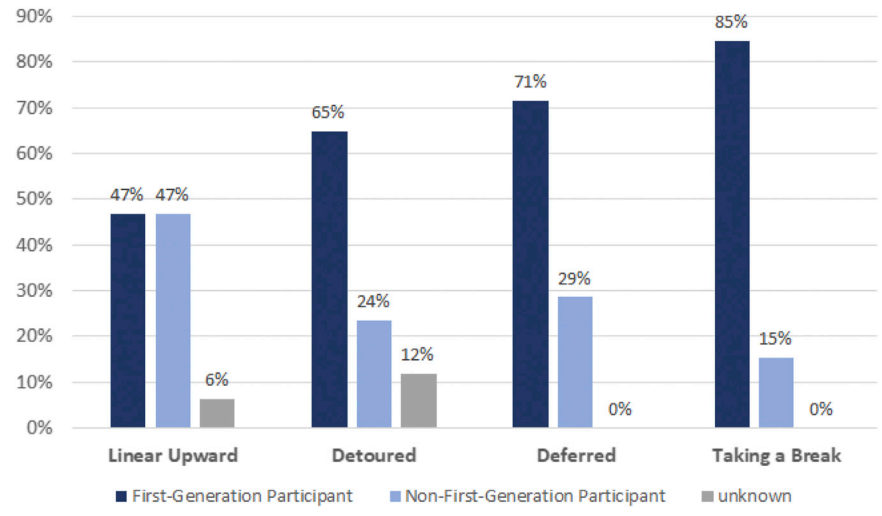


**FIGURE 3 |** Percentage of program participants on the four momentum trajectories by first-generation status.

the classroom experience for URM STEM students are worth exploring, as experiences for 2-year college students in the classroom have a significant impact on their success (McPhail, 2015; Wang et al., 2017b). The more than 20 faculty mentors for the ISP are invested in the success of the participants in the program and thus may be willing participants in professional development around improving their classroom practices to further increase URM student STEM success.

Though college contexts are unique, there are many aspects of the Madison College Inspire Scholars Program that show promise for increasing STEM transfer success for URM students enrolled at a 2-year college. It is important to note the interconnected nature of the supports put in place by the program to ensure a holistic support structure for the participants. That said, a few key interventions stand out as having the greatest impact on participant engagement and success. The most important components of the ISP were the tiered participation structure, and the bi-weekly meetings coupled with faculty mentoring. The meetings served various purposes that promoted successful STEM transfer. First, the meetings provided a means for participants to connect with one another and build community through shared experiences. The meetings were the only STEM-related events on campus where the majority of the participants were ethnic minorities, and the facilitators were peers (the peer leaders). Second, the professional and academic development training provided during the meetings was specifically designed to provide students with a road-map for successful transfer and to equip students with the knowledge and tools for its successful implementation. The faculty mentors were charged with ensuring that students participating in the ISP stayed on task and followed the road-map. So critical were the mentors that all participants regardless of role, were required to meet regularly with their mentors. Mentors were provided checklists of program responsibilities and important deadlines along with summaries of the bi-weekly meetings and asked to encourage their students to take action and apply what they had learned. Faculty mentors were also provided academic progress reports on their mentees in order to provide students with timely access to the resources needed to address any challenges encountered in their classes and thus stay on track in the curricular domain. The value of mentoring by faculty cannot be understated. Most minoritized students attending Madison College are first generation students with few family members or close friends with any experience successfully completing a college degree. Through their faculty mentor, each student had immediate access to someone who retained a wealth of knowledge and experience successfully navigating higher education and who was generally well connected at the college with access to significant college resources. Any transfer support program in order to be effective should include these or similar components that both build community among students of similar interests and also provide individualized academic support through mentoring.

On a final note, the analysis of first semester STEM QP brought some interesting patterns to the front that are worth consideration when developing an intervention such as the ISP. One consideration is how few of the students fit into a traditional postsecondary model with an easily definable first semester, and how little that mattered for transfer. Students that earned their first semester STEM QP during the program were completing transfer level STEM courses in other disciplines prior to the official "first semester" they attempted a transfer level math course. Even more striking, the students in the program that had experienced math remediation at some point at the college successfully transferred at a rate of 43.5%, more than double the baseline rate. It is therefore critical, when creating a program to support students interested in STEM transfer, if the goal is to truly broaden participation, to ensure the program is built with broad eligibility requirements. Colleges must remove barriers to participation in support programs by lowering minimum GPA requirements, allowing part-time students to engage with the supports, and most critically, allowing students to participate prior to completing college level math. Supporting students holistically through community, mentoring, and ensuring they take and successfully complete multiple STEM courses each semester, no matter their "level" is key to the success of the program and thus, the students.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because student data is protected through an IRB. Requests to access the datasets should be directed to bpsansinghelton@madisoncollege.edu.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.667091/full#supplementary-material

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# Variability in STEM Summer Bridge Programs: Associations with Belonging and STEM Self-Efficacy

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To address the challenges facing racial minority students majoring in STEM during the transition from high school to college, NSF funded Louis Stokes Alliances for Minority Participation (LSAMP) programs throughout the country implement summer bridge programs. Bridge programs vary in their focus on professional development, academic support, research experiences, social activities, and in other areas, but all share an intention to support students during their transition to college. Beyond retention, little is known about how these varied summer bridge experiences impact student outcomes in the first year of college. This study first describes the variability in the summer bridge programs in the Alabama LSAMP Alliance and then examines how differences in students' satisfaction with their experiences are associated with feelings of belonging and STEM self-efficacy, two factors associated with STEM retention. Students ($N$ = 145) who attended an LSAMP summer bridge program were surveyed at three time points over the first year of college. Findings indicated that bridge programs varied in their offering of academic classes, academic support (e.g., study skills), research experiences, professional development, and planned social activities. Students attending HBCUs scored more favorably than students at PWIs on some measures; however, these differences could be accounted for by satisfaction with bridge experiences. Satisfaction with specific aspects of the bridge programs, especially orientation activities and getting to know other students, were associated with feelings of belonging and STEM self-efficacy. These relations were stronger for belonging. Over the course of the academic year, the relations between bridge satisfaction and belonging and self-efficacy weakened.

**Keywords: LSAMP, summer bridge, stem majors, belonging, self-efficacy, college retention**



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## INTRODUCTION

The special challenges facing racial minority students majoring in STEM during the first year of college are well documented and include poor academic preparation, difficulty with social and academic integration, lack of disciplinary socialization, and racial discrimination (Carlone and Johnson, 2007; Carter et al., 2009; National Research Council, 2011). To address these challenges, Louis Stokes Alliances for Minority Participation (LSAMP) programs throughout the country have implemented best-practice strategies and high impact activities, such as summer bridge programs, to retain students in STEM (Clewell et al., 2006; National Research Council, 2011). The primary objective of this study is to examine how students' perceptions of summer bridge programs are related to belonging and STEM self-efficacy, two psycho-social characteristics associated with retention in STEM majors. A secondary objective is to illustrate the breadth of offerings and focus of successful summer bridge programs, which we hope will help other LSAMP alliances in creating summer programs.

Summer bridge programs are important because they are often the first point of contact between students and a higher education institution, major faculty, and collegiate peer group. Although broadly designed to improve retention, the specific objectives of summer bridge programs are far ranging and vary considerably:

> "Summer programs that include or target minority middle and high school and undergraduate students provide experiences that stimulate interest in these fields through study, hands-on research, and the development of a cadre of students who support each other in their interests (*p*. 10, National Research Council, 2011)".
>
> "Bridge programs are designed to address the personal and inhibiting institutional factors of undergraduate students as they transition into college and have been suggested to increase academic readiness, promote inclusion and integration into the college academic and social community, introduce the students to available supportive institutional academic support programs and services, and promote self-efficacy and persistence (*p*. 36 Grace-Odeleye and Santiago, 2019)".

As cases in point, the Challenge Program at Georgia Tech described by Murphy et al. (2010) consisted primarily of structured academic courses and a family support program. In contrast, an LSAMP program in Tennessee described by Howard and Sharpe (2019) had eight objectives that included academic course preparation, as well as objectives related to research experiences, motivation, and careers. This variability is also reflected in the Alabama LSAMP Alliance, which is the focus of the current research. One objective of this study is to describe the variation in the bridge programs at the nine campuses in this alliance, all of which were highly successful in the retention of students in STEM majors in the first year. The description serves as a resource for other programs considering a STEM bridge program for students from underrepresented racial groups.

Despite their variability, Clewell et al. (2006) note that LSAMP summer bridge programs share in common two characteristics, the integration of students into academic institutions and the socialization of students into their STEM profession. Thus, rather than focusing on retention, this study focuses on how students' experiences in summer bridge programs are related to two social psychological factors, belonging and STEM self-efficacy, that are associated with institutional integration, professional socialization, and retention over the course of the first year of college. Belonging refers to a sense of fit, identity, and support in a major (e.g., Walton and Cohen, 2007) and at a campus. Self-efficacy is a student's confidence that he or she has the necessary academic skills to pursue his or her major (e.g., Bong and Skaalvik, 2003).

This is an improvement over past studies of LSAMP programs, which have primarily considered retention and academic performance indicators (e.g., Howard and Sharpe, 2019). It is also important to consider that the adjustment tasks for first year students change over the course of the academic year as the challenge of academic classes increase. For these reasons, this study examined how students' perceptions of the summer bridge program are related to their sense of belonging and STEM self-efficacy at three time points over the first year of college: at the start of the fall term, the start of the spring term, and the end of the first year.

It is important to note that participants in the Alabama LSAMP program met and often exceeded institutional requirements for admission. For example, to receive an LSAMP scholarship, students must have a minimum 3.0 GPA and plan to major in a STEM field. As such, they would not be identified as at risk for dropping out solely based on their academic background. For this reason, this study focuses on factors associated with retention within a STEM major, rather than just retention in college.

## Theoretical Foundations

Arnett's (2000) theory of emerging adulthood identifies the college years as a period when individuals make critical decisions about marriage, careers, and childbearing. Although college students have taken great steps toward independence, their lack of experience and financial dependence makes this time period both one of vulnerability and rapid personal growth. At a time when parents, teachers, and friends are less available for support, college students choose a major and career path. Eccles' stage-environment fit model (Eccles, 2004) proposes that school transitions will have a negative impact on academic outcomes when there is incongruity between a student's needs and the social context of schools. College adjustment is often difficult because, compared to high school, classrooms are less personal with little opportunity to develop relationships with classmates and instructors. These problems are even greater when students are faced with large introductory STEM classes. In college, competition is more intense and expectations for autonomy and independence are greatly increased. These issues are often more challenging for students from underrepresented racial groups due to negative racial stereotypes and a lack of same-race peers, faculty, and role models (Carter et al., 2009; Grace-Odeleye and Santiago, 2019). LSAMP bridge programs are designed to ameliorate some of the stress of the immediate transition and guide students to successful completion of a STEM degree. In theoretical terms, they are designed to "fit" the needs of racial minority students as they embark on a STEM degree path.

A contribution of this study is its focus on the transition to college over the first year**.** Little attention has been given to the impact of summer bridge programs and the variation in students' experiences within these programs on the immediate transition to college and subsequent adjustment throughout the academic year. Both the emerging adulthood perspective and the stage-environment fit model suggest that the needs of students immediately after they come to campus will be different from those later in the semester. Little attention has been paid to how variation in students' experiences within these programs affects adjustment to college throughout the first year. Students' experiences and priorities during the first week of college are different from those at mid-term and the end of the academic year. Finding friends and a social niche give way to keeping up with coursework and stressing over exams. Career aspirations may take a backseat to the immediate challenges of surviving the first year of college. Bridge programs that focus on post-graduate opportunities at the expense of academic preparation and campus orientation may not meet the needs of students. Similarly, programs that include a research experience may promote students' STEM identity (Estrada et al., 2018), yet if students do not have the technical skills or enough disciplinary content knowledge to fully understand the project, their STEM self-efficacy and belonging may decline at the start of college. Importantly, because students who enter the LSAMP program vary in their background knowledge of their major and preparation, the same experience may impact students differently. For this reason, in this study the focus is on students' perceptions of their bridge experiences.

The choice to study STEM self-efficacy and belonging is motivated by numerous models of academic achievement and retention, some of which have focused on issues related to student race and ethnicity (e.g., Tinto, 1987; Wigfield and Eccles, 2000; Bandura et al., 2001; Lent et al., 2005; Hurtado et al., 2009). Although sometimes the labels change, most models identify academic self-efficacy and belonging as key factors in academic success. Self-efficacy has been found to be especially vulnerable during transitions at earlier time points in schooling (Eccles et al., 1993). Importantly, although STEM self-efficacy and belonging are often hypothesized to be related to success of programs targeting students in underrepresented racial groups (Lent et al., 2005; Carlone and Johnson, 2007; Hurtado et al., 2009), there is limited quantitative empirical research supporting these claims. (See Lent et al., 2005 for an exception.) This study seeks to fill this gap.

### Self-Efficacy

Independent of one's actual abilities, self-efficacy is a judgment of the probability of success at a task in an academic field, a vocation, etc. (Bandura et al., 2001; Bong and Skaalvik, 2003). Championed by Albert Bandura in his social cognitive theory, self-efficacy plays a critical role in achievement in that there is little incentive for people to take on academic tasks or persevere in the face of challenges unless they believe that their actions will lead them to success (Bandura et al., 2001; MacPhee et al., 2013). A great deal of research indicates that the perceptions of one's ability are better predictors of persistence and interest in an academic area than actual ability (Bandura et al., 2001). For example, even when men and women perform the same academically in math (as indexed by GPA, coursework, etc.), women tend to underestimate their abilities, whereas men do not, and this underestimation leads to women's eventual departure from STEM (Correll, 2001; Hill et al., 2010). LSAMP programs provide mentoring, emotional support, modeling, and guidance, all of which can be instrumental in promoting self-efficacy (Cabrera et al., 2013). MacPhee and colleagues (2013), for example, found in their study of STEM majors participating in a McNair program that women were initially lower than men in self-efficacy, but after completing the two-year mentoring program, self-efficacy ratings improved such that women were on par with men.

### Belonging

It is critical for college retention that students feel integrated into the larger campus setting and identify themselves as members of the larger college community (Tinto, 1987; Clewell et al., 2006). Belonging also describes students' feeling of fit with the culture of STEM (Cheryan et al., 2009; Cheryan et al., 2015) and their identity with a STEM profession. Campus integration and professional identity are both important for the retention of students and often more challenging for underrepresented racial groups (Walton and Cohen, 2011). First generation, minority, and low-income college students do not have access to the same information and resources as White and more privileged peers, making it more difficult to understand the college culture and expectations. Racial stereotyping and the stigma of being in a special program for racial minorities can create problems fitting in with a discipline and the larger campus at predominantly White institutions (PWI; Hurtado et al., 2009; National Research Council, 2011; Walton and Cohen, 2011). Programs such as LSAMP might succeed due to their ability to socialize students into the professional STEM culture, helping them to internalize a professional identity and to build solidarity with other professionals. In this study, we examine three components of belonging: how well students feel that they fit in with LSAMP programs and the larger campus (Cameron, 2004), STEM identity (commitment to, and desire for high performance in STEM; Chang et al., 2011), and the degree to which students feel supported by faculty at their institution.

## The Current Study

There are two aims to this study. The primary objective is to examine how students' perceptions of summer bridge program elements are related to belonging and self-efficacy over the course of the first year of college. Prior to addressing this objective, we describe the nine LSAMP bridge programs in the Alabama Alliance, all of which had nearly 100% college and STEM major retention over the first year. A comparison of the degree to which each program provided structured activities associated with best practices for STEM retention is offered to serve as a resource to other LSAMP programs in creating summer programs. Importantly, a bridge activity label provided by a campus director may not fully capture informal interactions during the program nor describe the depth and breadth of these activities. For example, faculty mentoring might occur in any activity where faculty are present, even if an activity is not specifically labeled as such. For that reason, we focus on student satisfaction with a common set of six experiences (academics, campus orientation, getting to know other students, research, professional development, and faculty mentoring) and how satisfaction is related to belonging and STEM self-efficacy. Examining these relations over the first year of college provides insight into the lasting impact of summer bridge programs.

# METHOD

## Sample

The nine campuses in the Alabama State alliance included five comprehensive state public institutions, one of which was an

HBCU. The other four were private minority serving institutions (i.e., HBCUs). The racial make-up of the institutions varied from nearly 100% underrepresented racial groups at the HBCUs to a range of 25%–43% at the PWIs. Statistics were not available for the percentage of racial minority students in STEM majors at each of the campuses. However, consistent with the national trends, we would expect their representation to be lower in STEM fields. In addition to the STEM bachelor's degrees offered at each institution, the five public campuses offered master's and doctoral degrees in STEM fields.

Similar to other LSAMP merit-based scholarship programs in the United States, a minimum high school GPA of 3.0 was established for entering freshman, and students had to meet any other admission criteria for the institution sponsoring the bridge program. All participants had to declare an intention to major in a STEM field. In bridge programs that required students to take academic summer school classes ($n = 3$), students must have maintained a 3.0 GPA in their summer classes to receive the scholarship for the upcoming academic term. In the first year and beyond, students had to maintain a 3.0 GPA and remain a STEM major to continue in the Alabama LSAMP Alliance. Participants in this study were students who attended a summer bridge program between 2017 and 2019 and completed at least one follow-up survey as described below (*Ns* = 145, 128, and 125, for the fall, early spring, and late spring time points, respectively). The group was 54.1% male and predominantly Black or African American (82.8%). Other racial groups represented included Hispanic or Latino (6.6%) and multi-racial (10.6%). Students provided their current major at each time point during the first year. The most recent major provided by students indicated the following percentages: 38% Engineering, 25% Biology and related fields (e.g., pre-Med), 19% Computer Science, 7% Biochemistry, 3% Chemistry, 2% Physics/Astronomy, 2% Mathematics, and 5% indicated another field.

A power analysis was conducted to assess the sample size needed to detect a medium effect size, with alpha = 0.05 and power ($1 - \beta$) = 0.80, and six predictors in the regression equation using G Power (Faul et al., 2009). A sample size of 90 would be able to detect a medium effect size ($f^2 = 0.17$). This sample size is met or exceeded in the analyses.

## Procedure

Prior to collecting data, the project was reviewed and approved by the Institutional Review Board at the authors' institution. Signed consent was obtained from students at the beginning of the summer bridge program. Campus directors at each institution provided the investigators with a schedule or syllabus for their summer bridge programs. Additional information was culled from campus reports provided each semester. The length of the bridge program and number of participants each year were noted. The activities listed in the schedules were reviewed by the investigators and categorized as described in the results section. The frequency and amount of time dedicated to an activity were noted.

Students completed surveys at the beginning of the fall term, early in the spring term (focusing on the previous fall semester), and late in the spring term at the end of the academic year (focusing on the spring semester). Survey items included in this study are available in the online supplement. Surveys were completed online for the first two time points, but at the last time point students completed the survey either online or in person at the spring student conference if they were in attendance. Students were paid $10 for each survey they completed. Surveys at each time point included several measures related to perceived academic abilities, belonging, support, STEM identity, and commitment to their major. Before the start of each survey, participants were reminded of their rights as research participants, including that their participation was voluntary, their answers were confidential, and they could withdraw at any time.

## Survey Measures

*Commitment to major* was assessed at the beginning of the fall and spring terms. Students indicated their commitment on a 7-point scale (7 = very committed, 4 = unsure, and 1 = not at all committed). At the third time point, students were asked how likely they were to change their major on a 7-point scale in which higher scores indicated greater likelihood of changing their major. At each time point, students who were considering changing their major indicated the new major (open-ended response).

*Belonging* was assessed with three measures, belonging to college/program, STEM identity, and faculty support. *Belonging* to the college and the LSAMP program were measured by eight items. Six items were related to belonging to the college (e.g., *I feel I have a sense of belonging to this college/university; I have a lot in common with other students on campus*) taken from Cameron's (2004) measure of in-group ties. Two additional items were author generated and related to belonging to the LSAMP program at their institution (*I feel like I have a lot in common with the other LSAMP students on campus*; *I feel a connection with the other LSAMP students on campus*). Items were rated on a 7-point scale (1 = strongly disagree to 7 = strongly agree). Reliability of the scale was high with $\alpha$ ranging from 0.89 – 0.91 across the three time points.

*STEM identity* was assessed using four items adapted from the Chang, Eagan, Lin, and Hurtado (2011; also see Espinosa, 2011) measure for biomedical and biological science majors. Students rated the importance of having a successful career, making a theoretical contribution, getting recognition from colleagues in their STEM field, and making a contribution that benefits society. The latter item replaced the Chang et al. item concerning finding a cure to a health problem. The desire to benefit society was substituted because of its similarity to the original item and due to findings that women and students in underrepresented racial groups often pursue STEM to help others (Carlone and Johnson, 2007; Thoman et al., 2015). Items were rated on a 4-point scale with higher scores indicating greater importance. Reliability of the scale was sufficient, with $\alpha$ ranging from 0.60–0.75.

*Faculty support* was measured by three items adapted from the Lubben et al. (2006) measure of social support. Students indicated how many faculty (none, one, two, three to four; five to eight, nine or more) they knew who they could call on for help; could talk to about private matters; could ask for help with a course or homework. Reliability of the scale was acceptable, with α ranging from 0.75–0.79 over the three time points.

As might be expected, the belonging to campus/LSAMP score was significantly correlated with the STEM identity and faculty support scores at each time point. Thus, to simplify the presentation of the results, the three scales were combined at each time point to create a Total Belonging score. Because the measures used different rating scales (4-point, 7-point and 9-point), scores were transformed to Z-scores and then averaged within each time point. Reliability of the combined measures was high, with α ranging between 0.87 and 0.88 across the three time points, further supporting this strategy.

*Self-Efficacy for STEM* academic performance was assessed by three items modeled after a measure developed by Lent et al. (2005), *How confident are you that you have the [math, science, spatial] skills necessary for your major?* Students responded using a 7-point scale (1 = no confidence and 7 = complete confidence). Responses were averaged to create a STEM Self-Efficacy score. Reliability was high, with α ranging from 0.81–0.86 across each time point.

*Summer bridge satisfaction* was assessed at the beginning of the fall term after all summer bridge programs were completed and included six questions focusing on students' satisfaction with specific aspects of the bridge program. The specific aspects of the summer bridge program included getting involved in research, professional development (presentations on careers in STEM, networking skills, resumes), academics (classes, refresher courses, study skills), orientation to the campus/program, getting to know other LSAMP students, and faculty mentoring/advising. Examples of each type of activity were provided. Students rated how well they thought each topic was covered during the bridge program on a 7-point scale (1 = not at all to 7 = very well). Mean satisfaction scores across the campuses indicated students generally had a positive view of the bridge programs, ranging between 5.18 ($SD$ = 1.81) for Research and 5.81 ($SD$ = 1.52) for Getting to Know LSAMP Scholars. Responses were also highly correlated (range 0.319–0.743, Median $r$ = 0.515). Thus, a Total Satisfaction score was also created by averaging responses across the six items. Coefficient alpha for Total Satisfaction was 0.86.

# RESULTS

## Analytical Approach for Quantitative Measures

Data have a nested structure in that students belong to one of nine institutions. Typically, this would lead to using statistical techniques, such a multilevel or hierarchical linear modeling (MLM, HLM), to take into account the lack of independence of student data within each institution. However, after reviewing relevant statistical guides, including O'Dwyer and Parker (2014), Maas and Hox (2005), Raudenbush and Bryk (2002), and Scherbaum and Ferreter (2009) this approach was deemed inappropriate for this study. Similar to all statistical procedures, the reliability of the results relies a great deal on sample size. In ordinary least squares (OLS) regression this depends on the number of cases in the analysis. In HLM, rather than the number of individuals, reliability depends on the number of groups at the highest level in the model, which is nine (i.e., the number of institutions) in this study. O'Dwyer and Parker (2014) suggest that fewer than 20–25 groups may not provide accurate estimates of regression coefficients. Maas and Hox (2005) ran several simulations and reported that a minimum of 50 groups with 20 individuals in each group are needed to avoid biased estimates. Scherbaum and Ferreter (2009) summarized previous studies on power and sample sizes and noted recommendations varied from 20–50 level 2 groups, depending on whether slopes or intercepts were being estimated. We fail to meet any of these recommendations. As a result, we proceeded using regression analyses to address the main research questions.

It should be noted that the sample sizes for the survey measures vary over time due to students failing to complete all of the surveys. *T-tests* were conducted comparing those who completed each survey to those who did not complete the survey on common measures at the previous time points. None of these comparisons were significant, suggesting that the variation in the sample size over time was not systematically associated with responses on the surveys.

## Description of LSAMP Summer Bridge Program and Commitment to Major

All bridge programs were held on campus and students generally stayed onsite in student housing. The number of students at each bridge site varied across the institutions and over time. At the low end were programs with five or fewer students and at the higher end were programs with eight or more students. The variability in size was a function of grant-imposed limits on funds available to each campus, recruitment of students, and the ability of students who were recruited to the LSAMP program to attend the summer bridge program.

There was considerable variability in the length of the bridge programs (**Table 1**). Three of the bridge programs ran concurrently with summer school, and students were enrolled in traditional summer school courses in addition to participating in other bridge activities. One of these ran all summer (~10 weeks), and the other two ran just one summer school session (~5 weeks). Three bridge programs were 10–12 days, and the remaining three were 5–7 days. Four of the programs ended only a short time before the fall term began. For the rest, there were several weeks between the end of the bridge program and when school started.

**Table 1** provides a summary of the common characteristics of the summer bridge programs based on the review of schedules and semester reports. Most of these characteristics are identified as "best practices" for retaining students in STEM, including academic support, research activities, and professional development/career planning experiences (National Research Council, 2011). These activities are listed in **Table 1** because there was considerable variability among the institutions in the degree to which these were included in their bridge programs.

**TABLE 1 |** Description of Summer Bridge Activities for Each Institution.

| Campus | Institution Type[a] | Bridge Length in Days | Academic Classes[b] | Academic Support[c] | Research[d] | Prof. Dev[e] | Planned Social[f] |
|---|---|---|---|---|---|---|---|
| 1 | HBCU Public | 11 | M | L-M | M-H | M | H |
| 2 | HBCU Private | 6 | L | H | L-M | H | L |
| 3 | HBCU Private | 12 | M | L | L-M | L | H |
| 4 | HBCU Private | 32 | H | M | L | H | L |
| 5 | HBCU Private | 4 | L | H | L-M | L | H |
| 6 | PWI Public | 35 | H | L-M | M | L-M | L |
| 7 | PWI Public | 70 | H | M | H | M | L-H |
| 8 | PWI Public | 12 | L-M | L-M | M-H | M | L-H |
| 9 | PWI Public | 5 | H | L | L | L | L |

Notes. *H = high, M = middle, L = low. There was some variation across the years in the content presented at different campuses that resulted in two classifications for an institution.*
[a]*All public schools offered advanced degrees in STEM. Private schools did not offer advanced degrees in STEM.*
[b]*Academic Classes: High = summer school courses; Middle = daily review session on selected topics over 1–3 weeks; Low = none.*
[c]*Academic Support: High = several sessions (at least 4) and topics occurring throughout a week; Middle = 2–3 sessions; Low = 1 or no sessions offered.*
[d]*Research: High = students developed a research project and presented it during the program; or several hands-on research activities; Middle = lab tours and research talks; Low = none.*
[e]*Professional Development: High = two or more sessions; M = one session; L = none.*
[f]*Planned Social Activities: High = at least one scheduled activity; Low = none.*

Not listed in **Table 1** is campus orientation, which all campuses included and had little variability. Orientation activities included campus tours, visits to or presentations from key non-academic support service centers (student services, campus safety) and welcoming remarks from administrators. Other activities not included in **Table 1** were idiosyncratic to specific campuses. These include community service activities, personal development (self-reflection activities), money management, and health education (HIV-AIDS). Additionally, time dedicated to faculty mentoring was not apparent in the summer bridge schedules, although during the academic year, faculty advising/mentoring meetings were common. These activities most likely occurred informally or in conjunction with other activities but were not singled out in the schedules. Next, a brief summary and comparison of the characteristics presented in **Table 1** is provided.

Most campuses (7 of 9) included *academic classes* in math or science. Traditional summer school classes were included in three programs (campuses 4, 6, and 7), in which students took two classes (usually a math and a required non-STEM course, such as English) offered in the regular summer school program. Academic review classes differed from summer school classes in that they were not credit bearing. These typically included math (typically algebra) and science (typically chemistry or biology). In **Table 1**, High = summer school courses; Middle = daily review sessions on selected topics over 1–3 weeks; Low = none.

*Academic support* included workshops and lectures on topics such as study skills, time management, and motivation. These offerings varied across institutions and the different years of the program. One campus (campus 4) primarily focused on these skills, offering several sessions each day of the program. Most covered 2–3 topics over the course of the summer, however, two programs did not include any of these activities in their schedules. In **Table 1**, High = several sessions (at least 4) and topics occurring throughout a week; Middle = 2–3 sessions; Low = 1 or no sessions offered.

*Research activities* included tours of faculty labs, research-oriented talks, and hands-on research activities. Two institutions (campuses 1 and 7) required students to develop a research idea that was presented at the end of the bridge program. Two institutions (campuses 4 and 9) listed no formal exposure to research as indicated on their schedules. In **Table 1**, High = students developed a research project and presented it during the program or participated in several hands-on research activities; Middle = lab tours and research talks; Low = none.

*Professional and career development* activities were not a central part of any program, but six of the programs had at least one session in this area. Session topics included presentations by campus career service organizations, resume writing, and explorations of STEM careers. In **Table 1**, High = two or more sessions; Middle = one session; Low = none.

Although all programs offered time for students to socialize outside of the bridge program, some programs built *social activities* into the formal schedule. These included leisure activities such as visits to local shopping areas and attractions, recreational activities (e.g., bowling), and picnics. The offerings varied from year to year with only three schools (campuses 1, 3, and 5) reliably offering more than two such experiences each year. In **Table 1**, High = at least one scheduled activity; Low = none.

Considering the information provided in **Table 1** as a whole, it can be seen that each of the nine campuses provided a unique experience for their students. The distinctiveness of each campus bridge program was included in the Alabama Alliance LSAMP proposal to NSF to allow each site the flexibility to address what they considered the challenges for first year students on their campus, as well as the strengths of their STEM programs. The activities cataloged are also listed as best practices for STEM retention (National Research Council, 2011).

Despite the variability among the summer bridge programs, retention of students in the program was quite high (meeting GPA minimums and having a STEM major), at nearly 100% at the end of the first year according to annual reports. Discontent with a major and an intention to change a major, however, may precede a student actually taking action to officially change majors. Thus, we examined students' commitment to their STEM major at each time point during the first year. Mean responses to the commitment to major question (possible range 1–7, with higher scores indicating greater commitment) were quite high at the Early Fall and Early Spring time points, Ms = 6.04, 6.01 *SDs* = 1.13, 1.08, respectively. Across the nine campuses mean commitment to major scores ranged from 5.6–7.0 for Early Fall, and 5.0–6.6 for Early Spring. A *t-test* comparison between the two time points was not significant, $t(116) = 0.31$, suggesting that generally commitment to major was stable over the fall term. At the Late Spring time point, students were asked to rate the likelihood that they would change their major and the mean score was 2.4, indicating a low likelihood of changing majors (where 1 = very unlikely 7 = very likely). Over the 3 years, 74 students who had attended a summer bridge program indicated an intention to change their major. However, within this group most ($n = 53$) indicated another STEM major as their alternate. Collectively, 89.4% of the summer bridge participants remained committed to a STEM major. Together, the evidence suggests that the summer bridge programs in the alliance were associated with high retention rates in STEM. We next turn to the association of satisfaction with the summer bridge program and the social psychological factors associated with Total Belonging and STEM Self-Efficacy.

## Relation Between Satisfaction with the Summer Bridge Program and Total Belonging and STEM Self-Efficacy

Before presenting the analyses associated with this objective, it is important to consider that students from underrepresented racial groups who attend HBCUs experience different campus environments from those at PWIs, regardless of their major or attendance at a summer bridge program (Winkle-Wagner and McCoy, 2018). *T-test* comparisons between students attending the two types of institutions on the bridge satisfaction measures indicated that students at HBCUs were more satisfied than those at PWIs, with marginally significant differences for two satisfaction measures ($p < 0.10$ for Research and Professional Development) and significant differences for three measures ($p < 0.05$ for Academic Support, Orientation, and Faculty Mentoring). The difference for Getting to Know LSAMP Scholars was not significant. Total Belonging was significantly higher at the Early Fall and Early Spring time points, and marginally significantly higher at the Late Spring time point for students at HBCUs compared to those at PWIs. However, STEM Self-Efficacy was only significantly higher for HBCUs at the Late Spring time point. As a result of these differences, in the regression analyses, a step-wise regression approach was taken to determine if the campus type accounted for any additional variance in Total Belonging or STEM Self-Efficacy after the bridge satisfaction measures were entered into the equation.

### Correlations Between Bridge Satisfaction and Belonging and STEM Self-Efficacy

Correlations between the Bridge Satisfaction measures (assessed at the Early Fall time point) and Total Belonging and STEM Self-Efficacy measures at each time point are presented in **Table 2**. At the Early Fall time point, each satisfaction measure was significantly or marginally significantly correlated with Total Belonging and STEM Self-Efficacy. At the Early Spring time point, Academic Support, Orientation, Getting to Know LSAMP Scholars and Total Satisfaction were correlated with Total Belonging, but none of the bridge satisfaction measures were correlated with STEM Self-Efficacy. At the Late Spring time point, Total Belonging was correlated with Academic Support, Orientation, Getting to Know LSAMP Scholars, and Total Satisfaction. In contrast to the Early Spring time point, at this third time point, STEM Self-Efficacy was positively correlated with each of the bridge satisfaction measures, except Getting to Know LSAMP Scholars. It is interesting to note that satisfaction with Academic Support, Orientation, and Getting to Know LSAMP Scholars were most consistently related to Total Belonging and STEM Self-Efficacy over the first year.

### Regression Analyses Predicting Total Belonging and STEM Self-Efficacy

The correlation analyses suggest that many aspects of the summer bridge programs have a positive impact on Total Belonging and STEM Self-Efficacy. Regression analyses were conducted to determine the combined impact of satisfaction with the summer bridge components on Total Belonging and STEM Self-Efficacy and to assess if attending an HBCU (over a PWI) accounted for variance on these two measures after taking into account the summer bridge experiences. Although it was highly desirable to assess if satisfaction with distinct components of the summer bridge program were differentially predictive of the outcomes, a challenge in these analyses was that the significant correlations among the bridge satisfaction measures could affect the reliability of the regression coefficients. Consequently, two sets of regressions were conducted. In the first set, Total Belonging and STEM Self-Efficacy at each time point were predicted by Total Bridge Satisfaction and HBCU vs. PWI status (HBCU = 1 and PWI = 0). Each of the predictors was entered in a stepwise manner, allowing for the assessment of the explanatory power of each ($R^2$ *change*). These analyses address whether attending an HBCU was associated with better outcomes after taking into account Total Satisfaction

**TABLE 2 |** Bridge Satisfaction Correlated with Total Belonging and STEM Self-Efficacy.

| Bridge Satisfaction | Early Fall *N* = 122 | | Early Spring *N* = 96–97 | | Late Spring *N* = 93 | |
|---|---|---|---|---|---|---|
| | Total Belonging | Self-Efficacy | Total Belonging | Self-Efficacy | Total Belonging | Self-Efficacy |
| Involvement in Research | 0.247** | 0.229* | 0.139 | 0.029 | 0.147 | 0.254* |
| Professional Development | 0.190* | 0.230* | 0.143 | –0.012 | 0.104 | 0.268** |
| Academic Support | 0.237** | 0.160$^{m}$ | 0.308** | 0.062 | 0.301** | 0.275** |
| Orientation to College | 0.407*** | 0.273** | 0.406** | 0.086 | 0.335*** | 0.224* |
| Getting to Know LSAMP Scholars | 0.361*** | 0.254** | 0.409*** | 0.167 | 0.216* | 0.122 |
| Faculty Mentoring/Advising | 0.297*** | 0.242** | 0.145 | 0.038 | 0.045 | 0.214* |
| Total Satisfaction | 0.378*** | 0.301*** | 0.338*** | 0.081 | 0.247* | 0.291** |

Note. *The sample sizes for correlations with Professional Development are one less than the stated N due to incomplete data from one participant on this measure. *p $\le$ 0.05; **p $\le$ 0.01; ***p $\le$ 0.001 (2-tailed).*

**TABLE 3 |** Regressions Predicting Total Belonging and STEM Self-Efficacy from Total Bridge Satisfaction.

| Predictors | Time 1 Early Fall | | Time 2 Early Spring | | Time 3 Late Spring | |
|---|---|---|---|---|---|---|
| | Total Belonging | STEM Self-Efficacy | Total Belonging | STEM Self-Efficacy | Total Belonging | STEM Self-Efficacy |
| **Step 1** | | | | | | |
| Total Bridge Satisfaction | 0.378*** | 0.301*** | 0.338*** | 0.081 | 0.247* | 0.291** |
| $R^2$ Change | 0.143*** | 0.090*** | 0.114*** | 0.007 | 0.061* | 0.085** |
| **Step 2** | | | | | | |
| Total Bridge Satisfaction | 0.345*** | 0.281** | 0.296** | 0.057 | 0.232* | 0.274** |
| HBCU vs PWI | 0.121 | 0.074 | 0.124 | 0.071 | 0.047 | 0.064 |
| $R^2$ Change | 0.014 | 0.005 | 0.013 | 0.004 | 0.002 | 0.004 |
| Total $R^2$ | 0.157*** | 0.095** | 0.128** | 0.011 | 0.063$^{m}$ | 0.089** |
| Total *F* | 11.07*** | 6.28** | 6.89** | 0.52 | 3.02$^{m}$ | 4.38** |
| Total *df* | 2, 119 | 2, 119 | 2, 94 | 2, 93 | 2, 90 | 2, 90 |

Note. *Entries for the satisfaction scores are standardized regression coefficients (beta). $^{m}$p < 0.10; *p $\le$ 0.05; **p $\le$ 0.01; ***p $\le$ 0.001 (2-tailed).*

**TABLE 4 |** Regressions Predicting Total Belonging from Bridge Satisfaction.

| Predictors | Time 1 Early Fall | | Time 2 Early Spring | | Time 3 Late Spring | |
|---|---|---|---|---|---|---|
| | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 |
| Bridge Satisfaction | | | | | | |
| Involvement in Research | 0.083 | 0.082 | –0.197 | –0.201 | 0.010 | 0.009 |
| Professional Development | –0.147 | –0.139 | –0.041 | –0.038 | –0.226 | –0.224 |
| Academic Support | –0.134 | –0.124 | 0.127 | 0.153 | 0.211 | 0.215 |
| Orientation to College | 0.381** | 0.350** | 0.305* | 0.238 | 0.296$^{m}$ | 0.285$^{m}$ |
| Getting to Know LSAMP Scholars | 0.204* | 0.215* | 0.324** | 0.347** | 0.116 | 0.119 |
| Faculty Mentoring/Advising | 0.157 | 0.139 | –0.034 | –0.067 | –0.085 | –0.089 |
| HBCU vs PWI | | 0.061 | | 0.135 | | 0.019 |
| $R^2$ Change | 0.236*** | 0.003 | 0.255*** | 0.014 | 0.162* | <0.001 |
| Total $R^2$ | | 0.238*** | | 0.270*** | | 0.163 |
| Model *F* | 5.85*** | 5.05*** | 5.09* | 4.64*** | 2.75* | 2.33* |
| Model *df* | 6, 114 | 7, 113 | 6, 89 | 7, 88 | 6, 85 | 7, 84 |

Note. *Entries for the satisfaction scores are standardized regression coefficients (beta). $^{m}$p < 0.10; *p $\le$ 0.05; **p $\le$ 0.01; ***p $\le$ 0.001 (2-tailed).*

with the bridge program. These results are presented in **Table 3**. The second set of analyses was similar, except in the first step the six individual bridge satisfaction measures were entered. The $R^2$ change statistic in the first step indicates the collective amount of variance in Total Belonging or STEM Self-Efficacy explained by these measures. These analyses also allowed us to see if there are some bridge satisfaction components that were more important than others in predicting these outcomes. Because of the issue of multicollinearity, these results should be considered cautiously. These results are presented in **Tables 4** and **5**.

The first set of regressions (**Table 3**) indicate that HBCU status did not significantly predict Total Belonging and STEM Self-Efficacy when Total Bridge Satisfaction was entered first in the analyses. With the exception of STEM Self-Efficacy at the Early Spring time point, Total Bridge Satisfaction was a significant or marginally significant predictor of the two outcome measures, with the variance explained ranging from 6% to 14% across the

**TABLE 5 |** Regressions Predicting STEM Self-Efficacy from Bridge Satisfaction.

| Predictors | Time 1 Early Fall | | Time 2 Early Spring | | Time 3 Late Spring | |
|---|---|---|---|---|---|---|
| | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 |
| Bridge Satisfaction | | | | | | |
| Involvement in Research | 0.069 | 0.068 | –0.051 | –0.053 | 0.062 | 0.059 |
| Professional Development | 0.079 | 0.086 | –0.099 | –0.097 | 0.071 | 0.080 |
| Academic Support | –0.187 | –0.177 | 0.059 | 0.074 | 0.173 | 0.184 |
| Orientation to College | 0.236m | 0.207 | 0.037 | –0.003 | 0.006 | –0.030 |
| Getting to Know LSAMP Scholars | 0.147 | 0.157 | 0.169 | 0.181 | –0.080 | –0.069 |
| Faculty Mentoring/Advising | 0.081 | 0.065 | 0.021 | 0.001 | 0.108 | 0.095 |
| HBCU vs PWI | | 0.057 | | 0.080 | | 0.064 |
| $R^2$ Change | 0.127* | 0.003 | 0.033 | 0.005 | 0.095 | 0.003 |
| Total $R^2$ | | 0.129* | | 0.038 | | 0.098 |
| Model *F* | 2.76* | 2.40* | 0.51 | 0.50 | 1.48 | 1.30 |
| Model *df* | 6, 114 | 7, 113 | 6, 88 | 7, 87 | 6, 86 | 7, 85 |

Note. *Entries for the satisfaction scores are standardized regression coefficients (beta). m$p < 0.10$; *$p \leq 0.05$ (2-tailed).*

three time points. Neither Total Bridge Satisfaction nor HBCU vs. PWI status significantly predicted Early Spring STEM Self-Efficacy. Together, these findings suggest that students' experiences with the summer bridge program may affect both Belonging and STEM Self-Efficacy over the first year of college. The next set of analyses explores whether satisfaction with specific aspects of the summer bridge program accounts for these relations.

For Total Belonging (**Table 4**), the amount of variance explained by Bridge Satisfaction measures was significant at each of the three time points, but was higher for the two earlier time points compared to the third (24%, 26%, and 16%, respectively). The addition of HBCU status in the second step failed to produce a significant increase in $R^2$ at any of the time points. A closer look at the beta coefficients in **Table 4** indicates that Orientation to College and Getting to Know LSAMP Scholars were the only significant predictors at Time 1 and 2, and there were no significant predictors at Time 3. The lack of significant predictors and the decline in variance explained at Time 3 suggests that over time the effects of the summer bridge program on belonging diminish.

For STEM Self-Efficacy (**Table 5**), the bridge satisfaction measures significantly predicted this outcome at Time 1, but not at any other time point (**Table 5**). Although the first step as a whole was significant, none of the individual Bridge Satisfaction scores were significant on their own. HBCU status did not contribute to the variance explained for any of the time points.

## DISCUSSION

The objectives of this study were to describe a range of successful summer bridge programs and examine how student perceptions of different program components are associated with belonging and STEM self-efficacy. As illustrated in **Table 1**, the programs varied considerably across a number of dimensions. The length of the summer bridge programs varied from an entire summer to 4–5 days. Some programs placed a strong emphasis on preparing students for STEM academic work through summer classes or review sessions. Those that did not offer these experiences instead emphasized providing academic support, such as study skills, time management, and motivation techniques (campuses 2 and 5). Hands on research or laboratory experiences were offered by three campuses (campuses 1, 7, and 8) and the others either offered laboratory tours or talks, or did not emphasize research at all. Despite this variability, satisfaction was high on all campuses, and once students entered the fall academic term, regardless of the content of the summer bridge program, they were very likely to maintain a minimum GPA of 3.0 and continue their pursuit of a STEM major.

It is important to note that each campus continued to offer programs to the LSAMP scholars throughout the academic year. Most had regular weekly or monthly meetings and provided opportunities for students to engage in research and professional development activities. All students were expected to attend the annual LSAMP conference toward the end of the spring term in which students presented research posters and attended talks and workshops. Thus, the success of the Alabama LSAMP program in retaining students cannot be attributed to the summer bridge experience alone. However, survey data collected early in the fall term before most of these other program elements had been implemented, suggests that the quality of student experiences in the summer bridge programs was related to important social psychological characteristics associated with persistence in STEM, especially during the first semester of college.

With respect to belonging, preliminary regression analyses indicated that Total Satisfaction with the summer bridge program was predictive of Total Belonging at each time point (**Table 3**). Additional regressions provided insight into how satisfaction with individual components of the bridge experience were related to Total Belonging at each time point. At the beginning of the fall term, student satisfaction with multiple elements of the summer bridge program was related to Total Belonging. Additional regression analyses allowed for the examination of the combined effects of the individual satisfaction measures and indicated a strong predictive relationship for Total Belonging, explaining up to

24% of the variance. Some caution must be taken in interpreting the *beta* coefficients in the regression models since the satisfaction measures are inter-correlated; however, the results suggest that satisfaction with Orientation and Getting to Know LSAMP Scholars may be the best predictors of belonging.

The second time point assessments took place after the first semester had ended. Correlations indicated that satisfaction with summer bridge Academic Support, Orientation, and Getting to Know LSAMP Scholars were still positively related to Total Belonging. Similar to the Early Fall time point, regression analyses indicated that satisfaction with the bridge experiences was highly predictive of Total Belonging, explaining up to 26% of the variance. Again, Orientation and Getting to Know LSAMP Scholars were more strongly associated with Total Belonging than the other bridge satisfaction measures. After HBCU status was entered at step 2 in the regressions, only Getting to Know LSAMP Scholars was significant.

At the end of the year, the pattern of correlations between Total Belonging and bridge satisfaction was similar to the second time point. Although the regression analysis was significant at the first step, the amount of variance explained was much less, about 16%.

Together these findings suggest that satisfaction with the summer bridge program had diminishing impact on feelings of belonging at the end of the first academic year. According to Eccles' stage-environment fit model (Eccles, 2004) this might be because bridge experiences are more attuned to helping students with the adjustment tasks at the beginning of the year (e.g., making friends, negotiating class schedules, and course expectations). Additionally, more recent experiences in the LSAMP program and on campus likely override experiences that occurred nine or more months earlier. As noted above, some caution must be taken in interpreting the *beta* coefficients in the models. However, in combination with the correlation results, they suggest that activities that help students orient to the college and provide a social bond among fellow LSAMP scholars might be especially important in creating a sense of belonging. Orientation activities may be effective because they reduce the anxiety associated with learning to negotiate a new living environment, such as finding classrooms and dorm life, as well as introducing students to key personnel and services (e.g., the registrar, financial aid, student health services). Developing social connections with other students is a key factor in student retention (Tinto, 1987; Walton and Cohen, 2011) and so it is not surprising that getting to know others is important. For STEM majors belonging to underrepresented racial groups, making these connections might be especially impactful (Walton and Cohen, 2011).

In contrast to belonging, the effects of satisfaction with the summer bridge program on STEM Self-Efficacy were less robust, explaining less variance compared to Total Belonging in nearly every analysis. Total Bridge Satisfaction (**Table 3**) was associated with STEM Self-Efficacy at the Early Fall and Late Spring time points, but the amount of variance explained was considerably less at the third (9%) than the first (14%) time point. When the components of Bridge Satisfaction were considered (**Table 5**), the overall regressions were only significant at the Early Fall time point and none of the individual Bridge satisfaction regression coefficients were significant. Additionally, the amount of variance explained by the satisfaction measures collectively ($R^2$ = 0.13), was much less than that explained for Total Belonging at the same time point ($R^2$ = 0.24).

It is curious that **Table 2** indicates that most of the summer bridge satisfaction measures were significantly correlated with STEM-Self-Efficacy at the Late Spring time point but were not individually significant in the regression analyses. This suggests that whatever accounts for these correlations is not independent across the bridge satisfaction measures, for example a generic positive feeling about the experience. Thus, there seems to be a cumulative or additive effect of these individual components. No one of them has a strong enough impact to produce a significant *beta,* but together the sum of their small impacts yields a significant $R^2$. More research is needed to understand this phenomenon.

Why was Total Belonging more strongly related to the summer bridge experiences than STEM Self-Efficacy? One possibility is that feelings of belonging may be more readily affected by the current social environment. The Total Belonging measure consisted of several components: belonging to campus and LSAMP, STEM identity, and faculty support. These beliefs are likely susceptible to the new experiences and social relationships formed in the summer bridge program. Bridge programs may be more successful at intervening in these areas than in areas related to academic self-concept. Confidence in math, science, and spatial skills is likely the result of many years of school experience. The additional courses and review sessions offered by most of the campuses in our alliance may not strongly affect students' confidence in their abilities, especially when the students have been high achievers in their high schools prior to joining the program. On the other hand, it is possible that the bridge programs are effective in maintaining students' high STEM Self-Efficacy during the first year of college, a time when it might be expected to drop (Eccles, 2004). Additional research that includes a non-intervention comparison group would help to understand this result.

An interesting finding in this study was that the advantages that HBCUs have over PWIs in promoting a sense of belonging and STEM self-efficacy were lessened by students' participation in the summer bridge program. Although this study only examined a limited set of outcomes, this finding is encouraging because it suggests that PWIs that engage in practices similar to the summer bridge program may provide significant support to these students.

There are some caveats and limitations to the findings presented so far. This study examined a variety of summer bridge programs, but these are only a small representation of the possible instantiations of LSAMP summer bridge programs throughout the country. Furthermore, although the sample was highly representative of the participants for three years of the program, they may not be representative of students across the U.S. Finally, the results do not extend beyond the first year of college. However, there are already multiple studies showing the efficacy of bridge programs for long-term retention of STEM students, (e.g., Clewell et al., 2006; National Research Council, 2011) Nevertheless, one purpose of the study was to show the variety and scope of different successful bridge programs, and we have been successful in meeting the objective. However, future research with a larger sample and a greater number of programs throughout the country is needed.

Several strengths must be noted as well. First, considering multiple time points throughout the first year provided a developmental perspective on the impacts of the summer bridge program. Not surprisingly, the effects are stronger for the first half of the school year compared to the end of the second semester. Second, this study considered two social psychological outcomes in the context of a program with a highly successful retention rate for STEM majors, rather than simply focusing on retention. Studying these factors may help researchers and educators understand why bridge programs are helpful to students. In this program, the promotion of feelings of belonging is identified as a possible explanatory factor.

In conclusion, this study contributes to the literature on best practices for the retention of students from underrepresented racial groups in STEM. It suggests that students' perceptions of summer bridge programs may be related to their future sense of belonging, and to a lesser degree, their STEM self-efficacy. Thus, beyond preparing students for the academic rigors of college, summer bridge programs may promote beliefs and attitudes that contribute to their success in their major.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Institutional Review Board at the University of Alabama. The participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

VA coordinated and managed the Alabama LSAMP Alliance. JB, SD, AB, and DM contributed to the conception and design of the study. JB and SD were primarily responsible for data collection. JB was chiefly responsible for writing the manuscript and conducting the analyses. SD, AB, and DM reviewed and approved the final version.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.667589/full#supplementary-material

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METHODS
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# Implementing a Hybrid Summer Transition Program

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The mission of the Virginia Commonwealth University Louis Stokes Alliance for Minority Participation (VCU LSAMP) program is to increase the retention and graduation rates of students from underrepresented racial and ethnic groups in science, technology, engineering, and mathematics (STEM) majors and those who matriculate into graduate programs. VCU LSAMP offers a hybrid summer transition program (HSTP) focused on facilitating the high school to college and two-year to four-year college transition process for students majoring in STEM disciplines. The goals of the program are to 1) build community among a cohort of students, 2) orient students to VCU, 3) prepare students for the academic rigors of their first year in a STEM discipline at VCU, 4) expose students to opportunities and careers in STEM, 5) engage them in the VCU LSAMP program, and 6) provide financial support. Five distinct components of the VCU HSTP are 1) a six-week online summer component, 2) a 1 week on-campus orientation, 3) a Design Project Challenge, 4) a transfer student track, and 5) an academic year component. Evaluation data reveals that the HSTP assisted participants with adjustment to the college schedule and setting, facilitated the formation of study groups, and increased overall motivation to graduate. The online courses helped familiarize students with both the academic topics in their chemistry and mathematics classes and the behaviors and norms of STEM majors. On average, participants in the HSTP had higher retention (85%) and graduation (73%) rates when compared with their peers (81% and 64%, respectively). Furthermore, those students who complete the online classes' requirements had a higher probability of receiving a grade of B or better in their first mathematics or chemistry class.

**Keywords: hybrid summer transition program, student success, community building, first year students, transfer students, LSAMP**

## INTRODUCTION

Founded in 2007 and funded by the National Science Foundation (NSF) Louis Stokes Alliance for Minority Participation (LSAMP), the Virginia-North Carolina Louis Stokes Alliance for Minority Participation (VA-NC Alliance) is a consortium of community colleges, historically black colleges and universities (HBCUs), predominantly white research institutions (PWIs), and a national research laboratory[1] The VA-NC Alliance's goals are to:

> diversify the science, technology, engineering, and mathematics (STEM) workforce with a focus on increasing the number of African American, Latinx/Hispanic, and Native American students, and students from Indigenous populations successfully completing baccalaureate degree programs, and increase and diversify the number of students that matriculate to graduate STEM programs.

Each institution has designed evidence-based programs informed by research to achieve the goals of the Alliance and to meet the unique needs of their students within their institutional cultural contexts.

As part of the VA-NC Alliance, the Virginia Commonwealth University LSAMP (VCU LSAMP) program has implemented its own set of community building, retention, and professional development programs to help achieve the overarching VA-NC Alliance goals of diversifying STEM and increasing graduate school matriculation rates. The VCU LSAMP anchor program for the past 7 years has been its hybrid summer transition program (HSTP).

This paper describes the hybrid summer transition program's evolution, implementation, and findings from assessment and evaluation data. An institutional context is provided and an overview of all VCU LSAMP activities. Each of the HSTP components are presented along with the research which informed the design and implementation of each component. Finally, the HSTP assessment results are presented.

## LOUIS STOKES ALLIANCE FOR MINORITY PARTICIPATION @VIRGINIA COMMONWEALTH UNIVERSITY

Virginia Commonwealth University (VCU) is a comprehensive, urban, public research university which enrolls approximately 30,000 undergraduate, post-baccalaureate, graduate, and professional students in 11 schools and three colleges.[2] Of those ~30,000 students, more than 20% of them are enrolled in a STEM undergraduate, graduate, or certificate program. Of the approximately 6,000 STEM majors, 28% identify with a racial or ethnic population that has been traditionally underrepresented in a STEM discipline. In the fall semester of 2020, approximately 24% of new VCU STEM students were transfer students. Similar to other large public institutions, VCU faces daunting challenges in its effort to provide a learning environment that is inclusive, that meets the needs of students with very different pathways to and preparation for college, and that is easily scalable given the constraints and complexities of a large university. Thus, VCU has invested in several initiatives and programs for both faculty and students. For example, VCU offers an Institute on Inclusive Teaching in STEM,[3] a faculty development program, Inclusive and Equitable Teaching Faculty Learning Community,[4] and the Leaders for Inclusive Learning Program[5]; all of which are geared toward institutional transformation to make VCU more inclusive and meet the goals established in the Diversity Driving Excellence theme of the University's Strategic plan.[6] In addition, the university has instituted a diversity and inclusion campus ratings system that provides diversity, inclusion, and engagement scores for each major unit on campus.[7] Furthermore, VCU has created several programs to meet the needs of its students, including the Acceleration Program,[8] the Summer Scholars Program[9] and the federally funded TRIO[10] and IMSD[11] programs to name a few. The VCU LSAMP program is one such program and it has evolved over the past decade and a half to meet the changing needs of its students and within the financial and other constraints placed on the program.

The VCU LSAMP program has offered various programs over its 13 years history. During this time several studies have been conducted to evaluate the programs and assess the influence those programs have on students' decisions to remain in STEM disciplines (Alkhasawneh and Hobson 2009; Alkhasawneh and Hobson 2010; Alkhasawneh and Hobson 2011; Alkhasawneh and Hargraves 2012, Alkhasawneh and Hargraves 2014; Brinkley et al., 2014; Griggs et al., 2016; Griggs and James, 2019). The current day VCU LSAMP programs include a hybrid summer transition program for new students including first time freshmen and transfer students, a spring transition program for new transfer students, a peer mentoring program, an academic success seminar in the fall semester, and career readiness series in the spring semester. In addition, several scholarships are offered including an emergency fund scholarship for which the need became glaringly evident after the first financial crisis in 2008–2009 and again with the COVID-19 pandemic. The program has an active listserv where work, research, volunteer, professional development, and scholarship

[1]https://lsamp.virginia.edu/about-our-alliance/ last accessed May 11, 2021.

[2]VCU's 11 schools and three colleges are: School of the Arts, School of Education, School of Social Work, Wilder School of Government and Public Affairs, School of World Studies, Robertson School of Media and Culture, School of Business, School of Medicine, School of Pharmacy, School of Nursing, School of Dentistry, College of Humanities and Sciences, College of Engineering, and College of Health Professions.

[3]https://lsamp.virginia.edu/about-our-alliance/ last accessed May 11, 2021.

[4]https://ctle.vcu.edu/initiatives/communities/ last accessed May 11, 2021.

[5]https://intranet.chs.vcu.edu/sponsored-programs/find-funding/internal-funding/leaders-for-inclusive-learning-program/ last accessed May 11, 2021.

[6]https://quest.vcu.edu/ last accessed May 11, 2021.

[7]https://inclusive.vcu.edu/dashboard/ last accessed May 11, 2021.

[8]https://dhsd.vcu.edu/programs/high-school/vcu-acceleration-vcua/ last accessed May 11, 2021.

[9]https://summerscholars.vcu.edu/ last accessed May 11, 2021.

[10]https://trio.vcu.edu/ last accessed May 11, 2021.

[11]https://healthdisparities.vcu.edu/researchtraining/undergraduate-programs/imsd/ last accessed May 11, 2021.

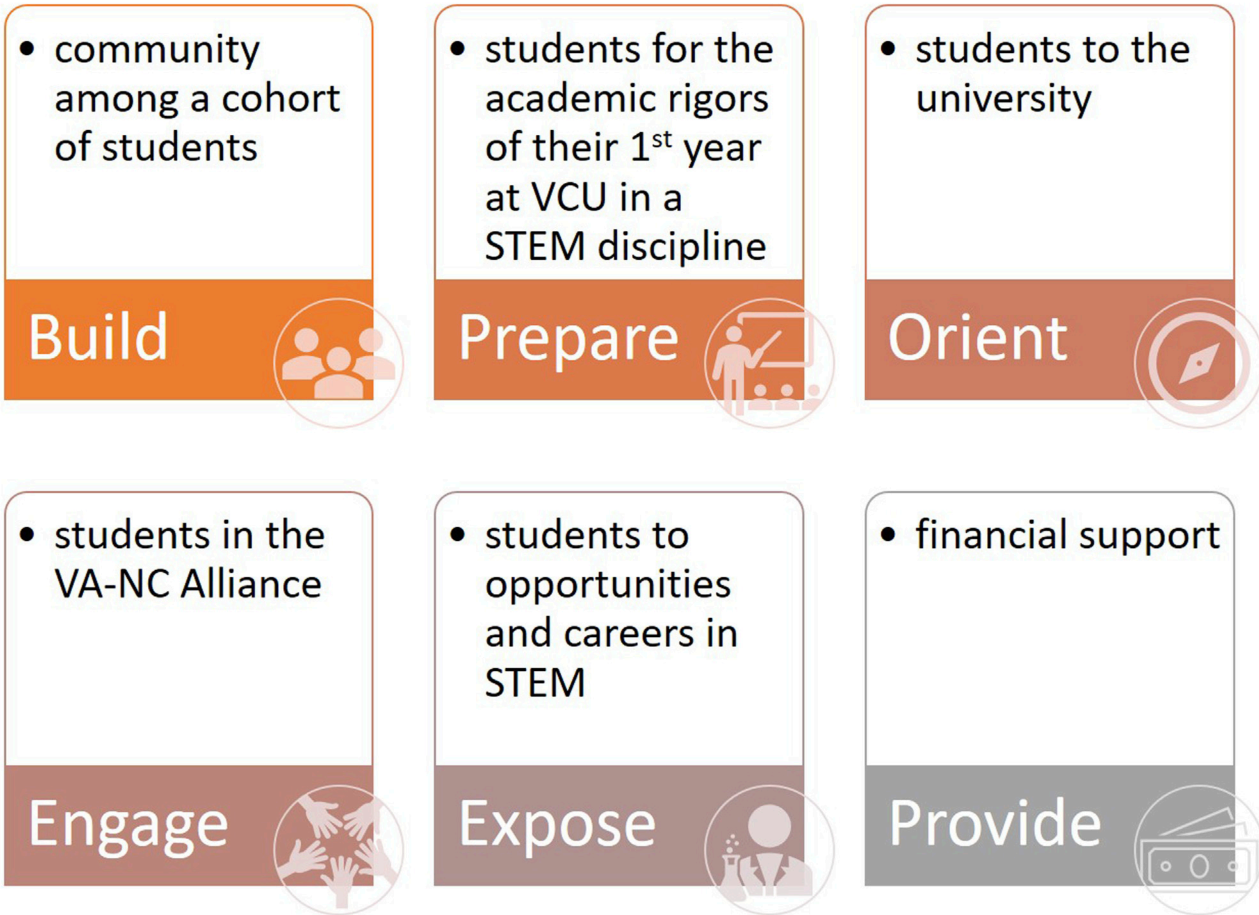



**FIGURE 1** | VCU-LSAMP Goals.

opportunities are shared as well as social events. Each semester the program holds an end of semester celebration, honoring the accomplishments of its graduating seniors. As the program has evolved over the years and the characteristics of each VCU LSAMP class is manifested, special events are planned to cater to the interests of the students. Together all these activities represent a robust collection of programs offered to the VCU LSAMP scholars. The cornerstone of the VCU LSAMP program is the hybrid summer transition program (HSTP).

## History and Evolution of the Summer Transition Program @Virginia Commonwealth University

The VCU LSAMP program first began in September 2007. At that time, prevailing wisdom and current literature had shown the importance of academic and social integration for the success of students (Pascarella and Terenzini 1980; Tinto, 1987; Strage 1999). Furthermore, studies have shown the importance of residential pre-college transition or bridge programs (Walpole et al., 2008; Stolle-McAllister et al, 2011) and peer mentoring (Budny et al., 2010; Rose et al., 2010; Hall and Jaugietis, 2011) in increasing the retention and graduation rates of students in STEM disciplines. Thus, the first VCU LSAMP programs consisted of a four-week summer transition program and a peer mentoring program which took place during the regular academic year. This paper focuses on the summer transition program. The goals of the summer transition program (**Figure 1**) are to:

Build community among a cohort of students,
Orient students to VCU,
Prepare students for the academic rigors of their first year in a STEM discipline at VCU,
Expose students to opportunities and careers in STEM,
Engage students in the VCU LSAMP program, and
Provide financial support.

In the inaugural VCU summer transition program (summer 2008) students earned six college credits in a precalculus course (4 credits), a study skills course (1 credit), and a science and engineering seminar (1 credit). Students also participated in professional development, social and community building activities, and toured local companies and research laboratories. Students were assigned an upper-class mentor with whom they met once a month during the academic year.

**TABLE 1 |** Summer Transition Program Topics for the varied modalities in which the program has been offered.

| Mathematics topics | Chemistry topics | Study skills topics |
|---|---|---|
| **On-campus summer transition program** | | |
| Real numbers | Chemistry basics | Study skills |
| Equations and inequalities | Measurements | Time management |
| Exponents and polynomials | Matter | Networking |
| Lines and systems | Atoms, ions, and molecules | |
| Functions and graphs | Formulas | |
| Rational expressions | Equations and moles | |
| Geometry | | |
| Trigonometry | | |
| **On-line summer transition program** | | |
| Real numbers | Math and algebra | Study skills |
| Equations and inequalities | Measurements | Time management |
| Exponents and polynomials | Matter | Networking |
| Lines and systems | Atoms, ions, molecules | |
| Functions and graphs | Stoichiometry | |
| Rational expressions | Simple reactions | |
| Radical expressions | Thermochemistry | |
| Geometry | | |
| Trigonometry | | |
| Exponential and logarithms | | |
| Limits and continuity | | |
| **Hybrid summer transition program** | | |
| Real numbers | Scientific notation | Introductions and VCU resources |
| Equations and inequalities | Units of measurement | Handling microaggressions |
| Exponents and polynomials | Elements and symbols | Time management and creating a schedule |
| Lines and systems | Molar mass and calculations | Finding study spaces and forming study groups |
| Functions and graphs | Equations for chemical reactions | Mindfulness |
| Rational expressions | Types of reactions | Effective listening and note-taking strategies |
| Radical expressions | Chemical quantities and reactions | Reading skills and test preparation |
| Geometry | | Presentations |
| Trigonometry | | Resume development, networking, and personal brand |
| Exponential and logarithms | | |
| Limits and continuity | | |

Eighteen students enrolled in and completed the on-campus program. The program had an 88% freshman-sophomore retention rate and a 61% six-year graduation rate of whom over half graduated with a STEM degree. While these figures were not optimal, they were higher than the VCU average at that time, which had an 83% freshman-sophomore retention rate and 50% six-year graduation rate for all students. As the program matured, it was tailored to suit the needs of the students and financial constraints of the program. Introduction to Chemistry was added to address student performance in General Chemistry (CHEM 101), which was shown to have a high rate of students earning a grade of D or F or withdrawing from the course (D, F, and W rate) especially among those students who identify as African American, Latinx/Hispanic, Native American, or are from Indigenous populations (AALANAI).

The on-campus summer transition program was offered from 2008 to 2011. The program typically enrolled between 15 and 21 participants, all of whom had gained full admission to an undergraduate STEM program at the university and had committed to attending VCU in the fall semester. Initially students were all enrolled in credit bearing courses; however, to reduce the financial burden of the program (paying for six credits for in state and out-of-state students) and to increase flexibility in the topics covered in the classes, the program switched to only offering a one credit bearing study skills seminar course and customized mathematics and chemistry courses (non-credit). This also made the program more appealing to students who may have placed into a higher mathematics class and thus were reluctant to "re-take" a precalculus class for which they had already received credit or placed out of. Furthermore, students placed in a lower-than-expected math class had the opportunity to retake the university math placement test at the end of the summer and place into a more advanced mathematics course. The mathematics and chemistry courses covered topics that had been identified by instructors as fundamental topics in which most students needed remediation or a refresher (**Table 1**). Students stayed in residential housing, were provided all meals, textbooks and supplies, and participated in field trips, laboratory visits, social activities, and orientation activities. Students who successfully completed the program by the end of the summer earned academic credit for the seminar course and a stipend, the amount of which was

**TABLE 2 |** VCU LSAMP Summer Transition Program modalities.

| Summer transition program year | | |
|---|---|---|
| **2007–2008** | Program location/duration: | On-campus–4 weeks |
| | Average cohort size: | 18 |
| | Courses offered: | Precalculus, investigations in learning (study skills), science and engineering seminar |
| | Academic credit: | 6 credits |
| | Financial incentive: | None |
| **2009–2011** | Program location/duration: | On-campus–4 weeks |
| | Average cohort size: | 18 |
| | Courses offered: | Precalculus, introduction to chemistry, study skills |
| | Academic credit: | 1 credit |
| | Financial incentive: | Max $200 awarded at the end of the summer |
| **2012** | Program location/duration: | Online–3 weeks with the option to continue courses |
| | Average cohort size: | 33 |
| | Courses offered: | Precalculus (ALEKS), introduction to chemistry (ALEKS), study skills |
| | Academic credit: | 0 |
| | Financial incentive: | Max $300 awarded at the end of the summer |
| **2014–2019** | Program location/duration: | Hybrid (~6 weeks online and ~1 week on-campus) |
| | Average cohort size: | 34 |
| | Courses offered: | Precalculus (ALEKS), introduction to chemistry (ALEKS), study skills |
| | Academic credit: | 0 |
| | Financial incentive: | Max $600 awarded at the end of the summer |

dependent upon their performance in the mathematics and chemistry classes. The decision to use financial incentives to increase student engagement with course work follows the positive engagement trends observed in literature in increasing student responses on end of year evaluations and on mile marker examinations (Goodman J., Anson R and Belcheir 2015; Sansgiry et al., 2006).

In 2012 the directors of the VCU LSAMP program made the decision to offer the summer transition program only in an online format. This change was motivated by the budget reduction experienced by the VCU LSAMP program and to increase participation. For example, in a typical year the on-campus program would cost approximately $40,000 for twenty students vs. the online program only $17,000 for double the number of students. Students who already had summer jobs or alternative plans for the summer were more willing to participate in an online program instead of an on-campus program. Furthermore, with advances in technology/software and the likelihood that more students had previous experience with online courses, the directors hypothesized that an online program would be well received and effective in achieving the goals of the programs. The online summer transition program (OSTP) was a three-week program and used an adaptive web-based intelligent assessment and learning tool, ALEKS[12] (Assessment and LEarning in Knowledge Spaces), for both the chemistry and mathematics preparatory courses. An online study skills course was also offered for the students utilizing a web-based learning management system, Blackboard.[13] Students who completed 70% of the ALEKS curriculum earned a stipend and the opportunity to retake the university placement test for math. The students were also allowed to continue the work on ALEKS throughout the fall semester, and if they were able to meet the 70% threshold by the end of the fall semester, they could still earn the stipend. All students, regardless of their completion rate, were assigned a peer mentor at the end of the summer for the academic year.

The program directors compared the costs, student outcomes, and assessments of the online and on-campus programs and found that the online program resulted in approximately a 40% decrease in overall costs and a 50% increase in participation (**Table 2**). In a comparison of on-campus transition program students and OSTP students who successfully completed the program (i.e., students who completed 70% of topics in the three courses), the students' academic performance in their mathematics and chemistry courses was comparable. Even though a stipend was offered to students who completed 70% of the ALEKS course topics in the mathematics and chemistry preparatory courses, only 70% of the OSTP students completed enough topics to earn the stipend by the end of the summer. While students in the online program believed the program helped prepare them for the academic rigors of their first year in a STEM major especially in mathematics and chemistry, they did not feel the program fostered community among the participants. They also did not feel that the program exposed them to opportunities and careers in STEM or oriented them to the various academic resources at VCU, two goals of the transition program. More comparison results are discussed in Brinkley et al. (2014). As a result of the OSTP comparison study findings, the VCU LSAMP leadership team designed a hybrid summer transition program and began offering the Hybrid Summer Transition program in the summer of 2014.

[12]https://www.aleks.com/

[13]https://www.blackboard.com/

## THE LOUIS STOKES ALLIANCE FOR MINORITY PARTICIPATION HYBRID SUMMER TRANSITION PROGRAM @VIRGINIA COMMONWEALTH UNIVERSITY

During a typical offering of the hybrid summer transition program (HSTP), the program is advertised to new students (freshmen and transfer) who have accepted admission to VCU, selected a STEM major, and who identify as a person from a racial/ethnic minority traditionally underrepresented in the STEM field, i.e., African American (Black), Latinx/Hispanic, Native American or are from Indigenous populations (in the Americas). Students are sent materials detailing the benefits of the program encouraging them to apply. Program facilitators select students from applications received based on essay responses, applicants' availability, and academic achievement. It is important to note that program facilitators try to ensure that a cohort has students with varying academic ability and achievement. Selected students are notified and given 2 weeks to commit to participation in the HSTP. The program tries to accept all applicants. However, when all applicants cannot be accommodated, students are able to participate in the Online Summer Transition program. Those who elect not to participate in the program remain on the VCU LSAMP listserv during the regular academic year. Upon acceptance students sign commitment forms acknowledging their understanding of program requirements and expectations.

The HSTP is intentional about selecting full time VCU faculty teach the ALEKS courses, providing the students an opportunity to build relationships with faculty and dismantling the stereotype that faculty want to see you fail or do not care about your performance in their classes. Program facilitators and coordinators are selected from graduate students who are participants in the nationally recognized Preparing Future Faculty Program,[14] are specializing in human development, or are developing an expertise in a STEM discipline and have also identified research interest in STEM education. All selected graduate students may be classified as Ph.D. students or are in their final stages of their Masters degree program. All facilitators receive continuous support and training from faculty and staff in their respective disciplines, the VCU School of Education, the VCU College of Humanities and Sciences, and the Office of Multicultural Student Affairs. Upperclass VCU LSAMP students are invited to serve the incoming cohort as peer mentors. Students are required to complete an application including a personal statement. Peer mentors are selected based on their current academic standing, essay responses, and availability. Students who are selected are required to participate and complete mentor training provided by Mentor Virginia.[15] Those who do not complete the training are not allowed to serve in a peer mentor capacity.

The approximately seven-week HSTP begins in early July with the online component and concludes in mid-August with a weeklong on-campus portion which includes an intensive Design Project Challenge, campus orientation, and peer mentoring introduction. A transfer student track is included in both the online and on-campus phases. The online component consists of three courses: study skills, mathematics, and chemistry. The study skills course utilizes Blackboard and the mathematics and chemistry courses utilize ALEKS. All students in the program take the ALEKS mathematics and chemistry courses regardless of their mathematics or chemistry course placement, however two study skills courses are offered, one tailored to the needs of first-time freshmen and the other to transfer students.

The one-week on-campus enrichment experience includes an intensive Design Project Challenge in which teams of 3–5 students are exposed to the concepts of ideation, design, research and in some cases prototyping. Students are tasked with posing unique design solutions to challenges facing society, all while exploring career options in STEM. Additionally, the on-campus orientation consists of research laboratory and industry tours, a ropes challenge course, student panels, an advising session, and continuation of the chemistry, mathematics, and study skills courses. The program concludes with an oral presentation and poster session during which the design projects are presented and judged and winners announced. All students participate in a final capstone community building exercise during which they reflect on the week's activities and lasting impressions. As created, the hybrid summer transition program offered both opportunities and incentives together to prepare students for a successful first year at VCU.

The program established a built-in incentive structure. While there are several academic, social, personal, and professional benefits to participating in the program, monetary rewards were also shown to motivate students to higher academic achievements; in addition to providing some students with much needed financial aid (Angrist et al., 2009). To qualify for the on-campus portion of the program students must successfully complete by a mid-summer date 1) all assignments given in the Study Skills course, 2) master 40% of the ALEKS chemistry topics, and 3) master 40% of the ALEKS mathematics topics. These qualifying HSTP students are granted early arrival into their residence halls. The HSTP students move into their residence halls one-week earlier than other students living on campus so they can participate in the on-campus portion of the HSTP. HSTP students are eligible for a modest stipend per course if they complete the following: 1) all assignments given in the Study Skills course, 2) mastered 80% of the ALEKS chemistry topics, and 3) mastered 80% of the ALEKS mathematics topics or a 25 point increase from their initial knowledge check (whichever is the lesser). Students who successfully complete 100% of the ALEKS chemistry topics can enroll in the General Chemistry course, waiving the prerequisite mathematics course requirements (if needed). The ALEKS® mastery levels were determined based on placement requirements established expectation by the in VCU chemistry and mathematics departments. The Design Project Challenge culminates in an oral and poster competition. The presentations are judged by STEM professionals from industry. Monetary awards are given to members of the teams who placed

[14]https://graduate.vcu.edu/development/faculty.html
[15]https://mentorva.org/training/

first, second, and third in the oral and poster competition. At the completion of the fall semester, students who earned a cumulative 3.0 GPA and have attended all the weekly fall seminar sessions receive an additional stipend.

## Study Skill Course

Universities have employed a variety of programs primarily designed to assist incoming students successfully transition to, and academically succeed in higher education settings. These university programs offer incoming students academic support in various formats such as peer and faculty mentoring (Johnson et al., 2007), individual academic advising and monitoring (Heisserer and Parette, 2002; Bloom, 2016), and specialized curriculum including study skills courses (Schwarz, 2016; Hacisalihoglu et al., 2020). Historically, these programs were designed to capture incoming freshmen students who may be academically underprepared. In some cases, students are encouraged or even required to participate in such programs based on factors such as high school GPA or ACT/SAT scores (Abrams and Jernigan, 1984). Study skills courses offered to incoming freshmen and/or transfer students in these programs typically cover various skills to improve academic self-efficacy through workshops on time management, reading techniques for textbooks, effective notetaking, resource utilization (e.g., libraries, student's services, etc.,), and study/exam-taking techniques. VCU offers two such elective 1 credit courses, UNIV 101 Introduction to the University and UNIV 102 Investigations in Learning. Following this model, the HSTP study skills course is designed to provide the necessary skills and tools for incoming STEM students, first-time freshmen and transfer students.

### Freshman Course

The HSTP freshman study skills course introduces participants to tools and strategies to prepare them for academic success. Throughout the course, students explore the following topics: 1) resources and microaggressions 2) time management, 3) study group etiquette, 4) learning styles, 5) mindfulness 6) listening and note-taking, 7) reading skills and test preparation, 8) presentation development, and 9) resume development, networking, and personal brand (**Table 1**). The course is designed to engage students prior to arrival on campus with a broad review of each of the nine modules during this online time period. Prior to arrival students focus on designing a plan of study for their coursework throughout the summer, including mathematics, chemistry, and study skills preparation. The plan of study is then modified throughout the duration of the program and utilized as a template for the start of the fall semester. Once on campus, students are immersed in exercises related to each of the nine modules and engage in reflection on how their learning has evolved during each class period and in comparison to self-paced review during the online portion of the program. These reflections are continued during the fall seminar course.

During the on-campus, portion students are held to course norms such as arriving to class on time, submitting assignments prior to the due date, and engaging in open dialogue. These norms establish accountability and are designed to foster habit formation. Prior to the beginning of each course period, the goals and objectives for the lesson are intentionally placed on the board, again establishing a routine for the students. It has been shown that more than 40% of the actions people perform on a daily basis are habits (Duhigg, 2012). Therefore, reiterating the course norms and goals daily initiates a habit loop for students to take with them beyond the on-campus portion of the HSTP and into their first semester as college students. These practices are revisited with students during the fall seminar course and emphasized with peer mentors to continue to reinforce the habits.

During the first module of the HSTP study skills course, students are engaged in icebreaker activities to increase participation, continuity among the group, and to provide important information about VCU resources that are in place for student success. Additionally, facilitators discuss microaggressions describing the history, identifying microaggressions (specifically focusing on racial microaggressions), and potential coping mechanisms to address microaggressions. During the second module, students learn about the basics of time management techniques. Interactive activities such as case studies are reviewed, compared, and discussed. Important components of these interactive activities address enhancing organization, avoiding procrastination, work-life balance, and focusing on self-care activities (e.g., hanging out with friends/family, watching TV, etc.,). Examples of case studies include comparing weekly schedules of midterms and an exam free weekly schedule. Furthermore, students are tasked with applying discussed techniques by creating a typical weekly schedule outlining social events, mentoring meetings, office hours, coursework, and class times.

Module 3 focuses on identifying appropriate study spaces, a topic of particular importance considering the emergence of remote learning surrounding the rise of COVID-19. Additionally, the importance of study groups is highlighted. Previous research has suggested that study groups are effective for increasing comprehension and grade point averages (Taraban et al., 2000). Along with identifying proper support structures and learning environments, students are encouraged to explore various learning styles in module 4, to align strategies for success with preferences in retaining material. These preferences such as visual, auditory, reading/writing, and kinesthetic learning provide students with an awareness of personally effective styles. In module 5, the concept of mindfulness is placed into practice. Mindfulness practices have been shown to enhance college student learning (Yamada and Victor, 2012). The HSTP participants explore the health benefits of mindfulness in their daily routines, including decreased stress/anxiety, improved concentration, and increased self-awareness and emotional wellbeing.

The primary topics of module 6 include honing effective listening skills and improving note-taking strategies. Group discussions are facilitated to compare, contrast, and apply current techniques. Additionally, the effects of using technology while note-taking are compared to traditional long-hand note-taking. In module 7, students are asked to discuss and complete activities on reading skills and exam preparations.

The last two modules prepare students for effective communication. In module 8, students gain tools for creating effective and captivating oral and poster presentations. They also learn how to properly address questions related to their presentations. In module 9, the final module, students focus on career preparation through a resume development workshop. They learn the power of networking and begin to cultivate a personal brand.

### Transfer Student Course

Researchers point out that both community colleges and 4-years institutions have responsibilities for ensuring the academic success and transition for transfer students (Jain et al., 2011). While the majority of the early research on STEM education has focused on early experiences at the K-12 and postsecondary levels with regard to examining their educational pathways, in more recent trends, scholars have turned their attention to understanding community college students' self-concept (Starobin and Laanan, 2005) and self-efficacy (Johnson et al., 2012) within STEM education. Community college ensures that students are ready and prepared academically, while 4-years institutions assist with transfer and transition (Berger and Malaney, 2003). Historically, community colleges have been identified as an important path for students of color, particularly for women of color entering higher education. Furthermore, community colleges offer more affordable tuition, flexible scheduling, smaller class sizes, access to faculty, and childcare compared to most 4-years institutions. As a result, community colleges may accommodate nontraditional students (e.g., students who may be older and/or have greater family and financial responsibilities) that have chosen to take a nonlinear path to degree completion (Pérez and Ceja, 2010). Thus, it was important to offer a transfer student track in the HSTP. Moreover, previous literature has highlighted the impressive rates of increase of AALANAI students within the community college system; however, despite this increase of students, low transfer rates by men and women of color make their recruitment into STEM from community college populations problematic, placing greater emphasis on the need for a program specifically tailored to the transfer students.

A unique variation of the study skills course is designed specifically for transfer students in the HSTP. Similar to the freshman study skills course, the following overarching topics are discussed: 1) resources and microaggressions, 2) time management, 3) study group etiquette, 4) learning styles, 5) mindfulness, 6) listening and note-taking, 7) reading skills and test preparation, 8) presentation development, and 9) resume development, networking, and personal brand. However, the presentations are customized to be more relevant to transfer students. In a similar manner the discussions vary to include nuances to fit the experiences of transfer students. The topics include:

- Finding and utilizing university resources.
- Fostering, advocating, and building positive (academic and social) relationships: peer to peer and faculty to student.
- Comparing and contrasting how these issues were handled while at their community college vs. how their approach may need to vary at VCU.

Moreover, each presentation on time management, note-taking, and study group etiquette consists of a quick overview and various interactive activities. Students reflect on previous experiences and scenarios are presented to spark a conversation about the pros and cons of various techniques. While mindfulness and resume development may be approached the same whether at a community college or a university, listening and note-taking skills or reading skills and test preparation may have to change when students now find themselves in a large lecture class of 300 or more students. Furthermore, by creating a community among the transfer students they are also building connections and a support network with their peers.

## Chemistry Course

ALEKS® is an online learning system using artificial intelligence to assess and provide instruction to students on a variety of topics (**Table 1**). This system provides an initial knowledge check testing students' previous topic mastery. Upon completion, students are provided with a personalized topic list to study and increase proficiency within the subject. This personalization allows students to learn at their own pace and only cover the topics needed. The VCU LSAMP program chose ALEKS in part because several incoming students were already familiar with the software because of prior use in high school. In addition, the VCU Chemistry and Mathematics departments have chosen ALEKS as their official preparation software for their required placement tests. Both departments have developed customized ALEKS courses by choosing the most important topics to master for first-year/transfer students and personalized videos covering the topics.

Traditionally VCU has used placement tests to determine which class level the student will start with during their first semester. In the Chemistry department, students must score at least a 30 out of 50 to be placed in General Chemistry (CHEM 101) their first semester. If students are unable to achieve this score, ALEKS can be used to show proficiency and thus be eligible to still register for the class. Students must achieve a 100% mastery of the ALEKS Introduction to Chemistry topics before registering for the General Chemistry course. Because of these requirements VCU LSAMP chose to use ALEKS and provides it free of charge to students in the HSTP. This allows the student to prepare for both placement tests and cover topics in a low stakes' environment. Professors and teaching aides provide online office hours during the summer to cover tough topics more in depth and provide a space for questions on the material. During the on-campus portion this shifts to in-person sessions. Each day students attend class taught by a Chemistry professor.

These hour-long sessions are a mix of oral presentations and hands-on worksheets. The topics covered align with the students' first 2 months of General Chemistry. Through ALEKS students review the topics and obtain a basic level of understanding. The on-campus sessions provide an opportunity to observe the structure of a college Chemistry class and increase their foundation before fall classes begin. Previous research showed 9 out of 10 students who completed ALEKS with 100%, passed the Chemistry placement exam (70% or better) and scored an average of 86.7 vs. 73.9 for the overall class during exam 1 (Polo 2011). Although the HSTP program requires students to only achieve 80% ALEKS Chemistry topics mastery to earn the stipend, HSTP students must master 100% of the ALEKS Chemistry topics to also place into the General Chemistry course otherwise Chemistry Department CHEM 101 prerequisites[16] must be met.

## Mathematics Course

The Department of Mathematics and Applied Mathematics piloted ALEKS Precalculus in 2015 after the VCU LSAMP program had already been using it for 2 years. After a successful pilot, half of the precalculus sections each semester used ALEKS while the other half maintained the large lecture format. During this time, a two-years study was conducted to verify that the performance was equitable across both instructional models. The ALEKS sections performed slightly worse on mechanical problems but showed a marked improvement on conceptual-type questions. For the 2019–2020 school year, all sections of the course were moved to the ALEKS model. Also, over this time, the university changed from the historical math placement test for incoming students to the ALEKS placement test.

Based on their scores on the placement test, students in the LSAMP program typically place into one of three math courses: College Algebra with Applications (Math 141), Precalculus (Math 151), or Calculus I (Math 200). Some students in the program who come with AP credits, dual enrollment credits or transfer college credits enter Calculus II, III or Differential Equations. Students who place in a class below calculus and want to enroll in a higher level can also use ALEKS to prepare for a placement retest. Students have been able to use the experience in LSAMP to improve their math skills and in turn, their math placement test score before classes begin. Students who place into the higher-level mathematics courses, utilize the LSAMP ALEKS mathematics course as a refresher, honing skills, and math techniques.

The math portion of the LSAMP HSTP begins with students working on ALEKS independently at home. The ALEKS template is the same as the one used for VCU's precalculus course during the school year (**Table 1**). The first step is to take the initial knowledge check. The artificial intelligence engine of ALEKS adapts to each student changing the difficulty and type of questions based on the student's responses. As the student progresses, the system determines the topics that a student is "ready to learn."

During the independent learning portion, the instructor holds weekly office hours for students to ask questions or to get clarification on a topic. The students come on campus for the last week of the program and attend an hour-long math session each day. To earn the stipend for the precalculus portion, a student must master 80% of the ALEKS mathematics topics. However, for students who placed into college algebra (below precalculus), they are able to earn the stipend if they achieve 75% mastery of topics or a 25 point increase from their initial knowledge check score, whichever is the lesser. As an example, a student placed into college algebra and scored a 46% on the initial knowledge check. If that student improves their performance to a 71% mastery by the completion of the program, they would receive the stipend.

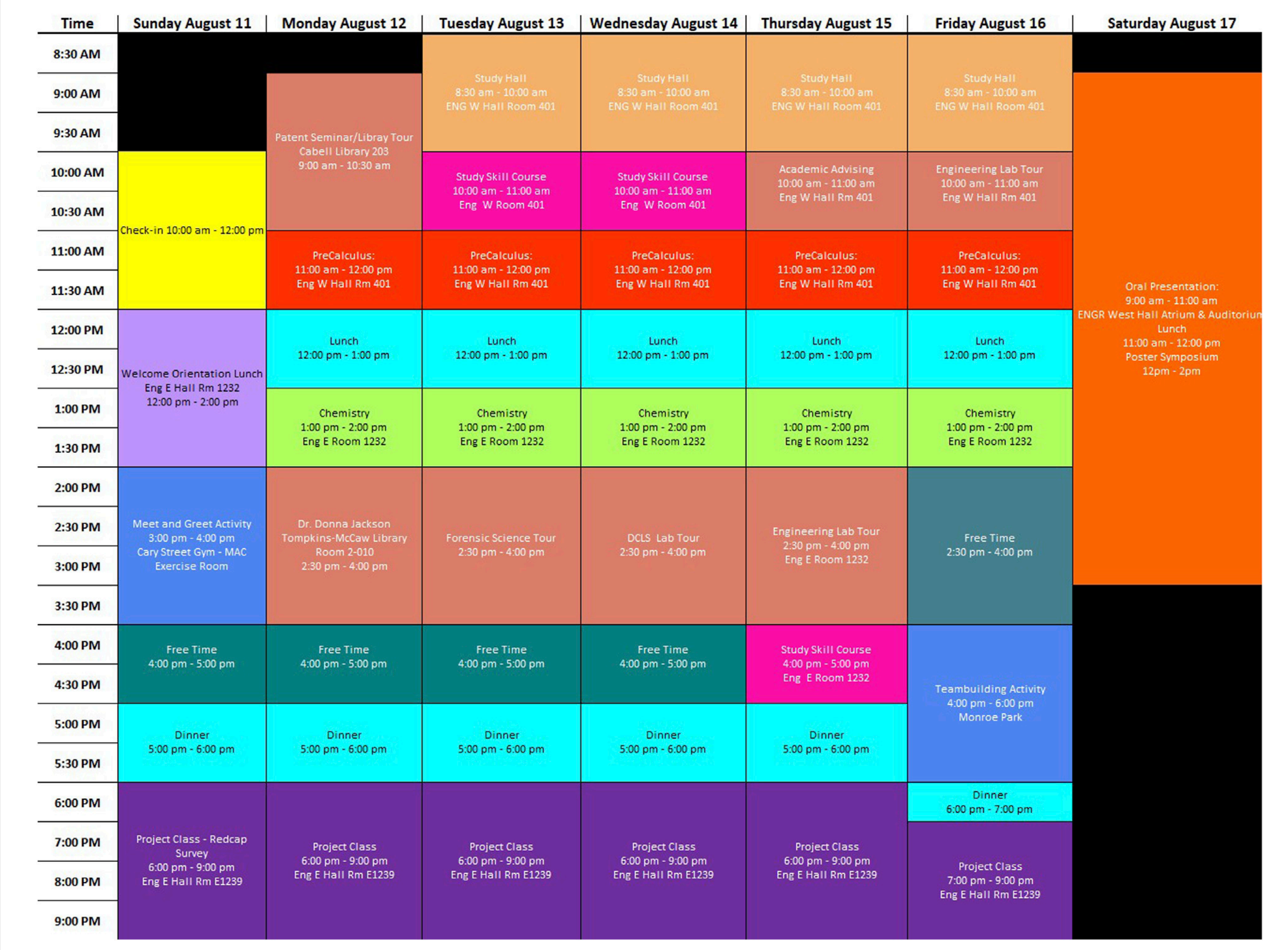
The goals of the on-campus portion of the math component of the program are 1) strengthen students core math skills, 2) alleviate the stress and worry some students may experience about math, 3) advance a student's mathematical knowledge, and 4) provide students a true, clear picture of what the experience in their math course will be when the semester begins. Every attempt is made to group students with mixed abilities to allow more peer-to-peer learning. This also allows students to realize their own capabilities at explaining concepts to their peers.

The material presented during this portion of the program is determined by gathering information from both ALEKS and the students. ALEKS provides a wealth of data and reporting including "topics attempted but not yet learned". (Topics in ALEKS can be unlearned, learned, or mastered.) Any topic that falls into this category with a percentage of 10% or greater is compared to the topics covered in college algebra and precalculus. These topics are key to the students' success in future math classes and are covered during this week. Exponent rules are an example of one such topic that typically makes the list. The week before students come to campus, they are surveyed about what math topics they find most difficult and intimidating as well as the topics that interest them the most. This information is compiled and constructed into a series of activities and lessons to solidify understanding of the selected topics.

## On-Campus Orientation

During the one week on-campus portion of HSTP, students move into their academic year residence halls a week prior to all other students, enabling them to form and strengthen intra-cohort connections. The goals aligned with the co-curricular portion of HSTP are to 1) familiarize students with campus resources, 2) expose students to various career options within STEM, and 3) build community among participating students, faculty, and staff. Along with the curricular aspects of the program, students are immersed in a dynamic array of activities ranging from hands-on workshops, guest lectures, and engagement with professional advisors in preparation for the fall semester (**Figure 2**). At the beginning of the week, participants engage in team bonding through obstacle course challenges including high and low ropes activities. Each cohort is challenged with stepping outside of their comfort zone, trusting in their team members to overcome obstacles and complete the assigned tasks. The bonds formed between the students during these early activities contribute significantly to

[16]MATH 141, MATH 151, MATH 200, MATH 201 or satisfactory score on the VCU mathematics placement test within the one-year period immediately preceding the beginning of the course; and CHEM 100 with a minimum grade of B or satisfactory score on the chemistry placement exam/assessment within the one-year period immediately preceding the beginning of the course.



| Time | Sunday August 11 | Monday August 12 | Tuesday August 13 | Wednesday August 14 | Thursday August 15 | Friday August 16 | Saturday August 17 |
|---|---|---|---|---|---|---|---|
| 8:30 AM | | | Study Hall 8:30 am - 10:00 am ENG W Hall Room 401 | Study Hall 8:30 am - 10:00 am ENG W Hall Room 401 | Study Hall 8:30 am - 10:00 am ENG W Hall Room 401 | Study Hall 8:30 am - 10:00 am ENG W Hall Room 401 | |
| 9:00 AM | | Patent Seminar/Libray Tour Cabell Library 203 9:00 am - 10:30 am | | | | | Oral Presentation: 9:00 am - 11:00 am ENGR West Hall Atrium & Auditorium Lunch 11:00 am - 12:00 pm Poster Symposium 12pm - 2pm |
| 9:30 AM | | | | | | | |
| 10:00 AM | Check-in 10:00 am - 12:00 pm | | Study Skill Course 10:00 am - 11:00 am Eng W Room 401 | Study Skill Course 10:00 am - 11:00 am Eng W Room 401 | Academic Advising 10:00 am - 11:00 am Eng W Hall Rm 401 | Engineering Lab Tour 10:00 am - 11:00 am Eng W Hall Rm 401 | |
| 10:30 AM | | | | | | | |
| 11:00 AM | | PreCalculus: 11:00 am - 12:00 pm Eng W Hall Rm 401 | PreCalculus: 11:00 am - 12:00 pm Eng W Hall Rm 401 | PreCalculus: 11:00 am - 12:00 pm Eng W Hall Rm 401 | PreCalculus: 11:00 am - 12:00 pm Eng W Hall Rm 401 | PreCalculus: 11:00 am - 12:00 pm Eng W Hall Rm 401 | |
| 11:30 AM | | | | | | | |
| 12:00 PM | Welcome Orientation Lunch Eng E Hall Rm 1232 12:00 pm - 2:00 pm | Lunch 12:00 pm - 1:00 pm | Lunch 12:00 pm - 1:00 pm | Lunch 12:00 pm - 1:00 pm | Lunch 12:00 pm - 1:00 pm | Lunch 12:00 pm - 1:00 pm | |
| 12:30 PM | | | | | | | |
| 1:00 PM | | Chemistry 1:00 pm - 2:00 pm Eng E Room 1232 | Chemistry 1:00 pm - 2:00 pm Eng E Room 1232 | Chemistry 1:00 pm - 2:00 pm Eng E Room 1232 | Chemistry 1:00 pm - 2:00 pm Eng E Room 1232 | Chemistry 1:00 pm - 2:00 pm Eng E Room 1232 | |
| 1:30 PM | | | | | | | |
| 2:00 PM | Meet and Greet Activity 3:00 pm - 4:00 pm Cary Street Gym - MAC Exercise Room | Dr. Donna Jackson Tompkins-McCaw Library Room 2-010 2:30 pm - 4:00 pm | Forensic Science Tour 2:30 pm - 4:00 pm | DCLS Lab Tour 2:30 pm - 4:00 pm | Engineering Lab Tour 2:30 pm - 4:00 pm Eng E Room 1232 | Free Time 2:30 pm - 4:00 pm | |
| 2:30 PM | | | | | | | |
| 3:00 PM | | | | | | | |
| 3:30 PM | | | | | | | |
| 4:00 PM | Free Time 4:00 pm - 5:00 pm | Free Time 4:00 pm - 5:00 pm | Free Time 4:00 pm - 5:00 pm | Free Time 4:00 pm - 5:00 pm | Study Skill Course 4:00 pm - 5:00 pm Eng E Room 1232 | Teambuilding Activity 4:00 pm - 6:00 pm Monroe Park | |
| 4:30 PM | | | | | | | |
| 5:00 PM | Dinner 5:00 pm - 6:00 pm | Dinner 5:00 pm - 6:00 pm | Dinner 5:00 pm - 6:00 pm | Dinner 5:00 pm - 6:00 pm | Dinner 5:00 pm - 6:00 pm | | |
| 5:30 PM | | | | | | | |
| 6:00 PM | Project Class - Redcap Survey 6:00 pm - 9:00 pm Eng E Hall Rm E1239 | Project Class 6:00 pm - 9:00 pm Eng E Hall Rm E1239 | Project Class 6:00 pm - 9:00 pm Eng E Hall Rm E1239 | Project Class 6:00 pm - 9:00 pm Eng E Hall Rm E1239 | Project Class 6:00 pm - 9:00 pm Eng E Hall Rm E1239 | Dinner 6:00 pm - 7:00 pm | |
| 7:00 PM | | | | | | Project Class 7:00 pm - 9:00 pm Eng E Hall Rm E1239 | |
| 8:00 PM | | | | | | | |
| 9:00 PM | | | | | | | |

**FIGURE 2 |** VCU-LSAMP Sample Orientation Week schedule.

the participant engagement, buy-in, and accountability throughout the remainder of the program.

Students are introduced to on-campus and off-campus facilities and centers such as the university library, the writing center, engineering laboratories, forensic science laboratories, the Division of Consolidated Laboratory Sciences, the Office of Multicultural Student Affairs, and the Well (a student wellness center). They hear from speakers including representatives from Career Services and Financial Aid and engage in interactive discussions with both undergraduate and graduate student panels to gain insight into student life. To provide time to practice what they have learned in their classes, students participate in a study hall session.

Students' physical presence on campus enables them to become acclimated to the campus, providing them with the confidence to navigate their whereabouts at the commencement of the fall semester. The full schedule and team building exercises help students form bonds with each other. At the conclusion of the on-campus portion of HSTP, students gather in a circle to reflect on their experiences. Each participant holds onto a thread and shares something that they have learned throughout HSTP and/or something that they valued during their experience. They then pass along the thread to the next person until everyone in the circle has had an opportunity to share. The circle becomes a web of connections, symbolic of the relationships they have created throughout their experience in HSTP (**Figure 3**). During this final reflection activity, the overwhelming response from students is that what they value the most from their HSTP experience are the friendships they make throughout the summer, especially during the orientation week, and the family they create within VCU LSAMP.

## Design Project Challenge

A unique feature of the HSTP is the Design Project Challenge (DPC). The DPC was first introduced with the advent of the HSTP. The goal for the Design Project Challenge is to introduce students to topics of project ideation, design, research, and product prototyping. The desired learning outcomes of the design challenge are as follows:

Engage students in personally relevant STEM inquiries
Develop communication skills

**FIGURE 3 |** VCU-LSAMP Closing community building activity.

Foster team building and social integration
Build confidence as a STEM student
Expose students to the concepts of product design and research

Student design teams consist of 3–5 students with similar interests but may differ in major. Each team brainstorms and defines a unique societal problem to address, specifically ones that are personally and/or culturally relevant and interesting to them. Seminars provide instruction on topic development, research techniques, and discussing additional resources in the collegiate setting. A project pitch is incorporated into their development process. Students present their ideas to other program participants, VCU LSAMP staff, and other college faculty members from College of Engineering, College of Humanities and Sciences, School of Business, and School of Medicine. An environment of creative and critical thinking and peer collaboration is enhanced with students' participation in "mini-challenges." The design process concludes with formal research papers and posters of their project. At the closing ceremony each team delivers an oral presentation to be judged. The top three teams are awarded additional stipends and a chance to continue their project with the additional guidance of the design course instructor, VCU faculty, and support from VCU's entrepreneurial, cross-discipline da Vinci Center for Innovation.

While the overall structure of the Design Project Challenge has remained the same, the competition has evolved over the years. Each team is required to write a concept paper, design a poster, and give an oral presentation at the end of the week. However, in the more recent years teams can develop physical prototypes of their ideas in addition to the written requirements. As a result of increased interest in prototyping, hands-on activities, including the use of open-source electronic prototyping platform Arduino, utilizing the university's 3D printer, and an introduction to patenting information by the university's library has been included. Additional metrics have been added to design team formation, including a personality assessment prior to the on-campus experience.

## Academic Year Components

While the HSTP is the cornerstone component of the VCU LSAMP program, two other programs complement the HSTP, the Peer Mentoring Program and the fall semester Academic Success Seminar. Students who participate in the HSTP are expected to also attend the Academic Success Seminar (as indicated in their commitment form).

### Peer Mentoring Program

Multiple studies have identified social integration into the college community as an important factor toward the retention of students (Tinto, 1993; Holland et al., 2012; Collier, 2017). There is significant evidence of mentoring contributing to an overall positive relationship between students, their major, and their university. Traditionally, LSAMP upperclassmen are assigned mentees during the on-campus portion of the summer hybrid program. Utilizing the near peer model (Zaniewski and Reinholz, 2016), a selected VCU LSAMP upperclassmen are matched with one or two freshman students based on similarity in majors, career goals and personal interests, and social identities. The goal of the mentorship program is to help new students become acclimated to college life and feel integrated in VCU LSAMP. Mentors are required to correspond with their mentee(s) at least once every week by email, phone, or video chat. Mentors are also instructed to meet with their mentee(s) in person on at least a monthly basis. A common response in the evaluation survey for the Mentorship Program expressed the satisfaction of students having someone to go to with their questions. Most students identified their mentors as a positive source of support and felt comfortable discussing academic and non-academic topics with them. These responses illustrate an observation from a study by Meyers et al. at Notre Dame, stating that students felt more comfortable reaching out to upperclassmen vs. faculty (Meyers et al., 2010).

### Fall Semester Academic Success Seminar

To achieve the goals of continued engagement in the VCU LSAMP program a fall academic success seminar was introduced as a required component of the HSTP. This custom designed course for VCU LSAMP students continues the themes covered in the HSTP Study Skills course and is similar to the UNIV 101 Introduction to the University and UNIV 102 Investigations in Learning, courses offered by VCU, neither of which are required courses. Providing structured dedicated time to reinforce concepts covered during the summer study skills course and an opportunity for students to see their friends from their cohort was found to be important to the participants in exit surveys. This seminar also provides VCU LSAMP directors an opportunity to check in with the students, monitor their self-reported academic progress and become aware of any academic needs such as tutoring, internships, recommendations, etc. Upper-class LSAMP students also attend the Academic Success Seminar on occasion to say hello and catch up with the directors and meet the new cohort. These weekly meetings not only provide content but also an opportunity to continue to build relationships. Research has shown this form of proactive advising and holistic care is beneficial to students (Heisserer and Parette, 2002; Packard et al., 2013; Bloom, 2016; Lane, 2016).

The Academic Success Seminar meets once a week during the fall semester (**Table 3**). This course gives students an opportunity to discuss their first-year experience. The tools and techniques students learn in the course help them to combine their skills, knowledge, and talents to assist them in recognizing what motivates them and helps them transition into a successful college career. Questions explored during the course include:

What are your key strengths?
What are your core values?
What are you passionate about?
Who should sit on your personal advisory board?
How does emotional intelligence fuel knowledge and talent?
How will you recognize and deal with bias?
How to "lean in" against the odds?
What do resilience and conflict resolution look like?

During the course students were asked to complete reflection exercises such as journaling, discussion circles, and personal assessments (e.g., Strengths Finder, Let Me Learn etc.,). Students are also asked to read selected materials, watch Ted Talks, and listen to Podcasts.

## PROGRAM OUTCOMES AND FINDINGS

### Methodology

Between 2014 and 2019 over 200 students participated in the HSTP program ($n$ = 201).[17] The participants majored in one of the 15 undergraduate STEM[18] disciplines offered at VCU, identify as AALANAI,[19] and approximately 65% of the participants were women. Findings are reported from data collected from the HSTP 2014-2019 programs. Academic achievement data was gathered from 2014-2020. Program staff observations of the participants were also used. The evaluation data reviewed were from end of program surveys administered at the completion of each summer (2014-2019), bi-annual focus groups and interviews that were conducted in 2016 and 2018, and survey data that was collected from an in-progress research project that was administered in 2018. Three 50-minute focus groups were asked to respond to seven open-ended questions (see **Table 4**). Two groups were facilitated by program staff and the third was conducted by a non-program affiliated graduate education researcher. For the interviews, more than two dozen students were interviewed by program staff to explore the student perceptions of the impact of the program more fully. All enrolled VCU LSAMP students were invited to participate in the focus groups and interviews, thus multiple cohorts were represented in the focus groups and during the interviews. Students signed up to attend the focus groups or participate in an interview. The goal of the focus groups and interviews was to explore the student perceptions of the impact of the program more fully.

Qualitative data from the focus groups and interviews were analyzed following Creswell's description of the systematic process of data analysis in grounded theory (Creswell, 1998). Select members of the research team first reviewed recordings of the focus groups and interviews independently to develop codes and identify themes in the responses to the questions. They then met to review their findings and developed, sorted, compared, and contrasted codes and categories until no new codes were created. Data from the program evaluation and research surveys, focus groups, interviews, participant observation present a comprehensive picture of the outcomes of the HSTP program over several years. Academic achievement data collected includes performance in HSTP classes and university courses, retention, graduation, and declared major data. All data are presented in aggregate per IRB approval (HM#20001406).

### Academic Outcomes

The six-year graduation rate for HSTP students was 72.7% (HSTP summer 2014), which is approximately 10% points higher than the university average for the same population (AALANAI students) over the same time period. Of the HSTP students

[17]Due to the uncertainty resulting from the COVID-19 pandemic, only the Online Summer Transition program was offered in 2020, thus the data from summer 2020 is omitted from the program analysis.

[18]VCU STEM majors include bioinformatics, biology, biomedical engineering, chemical and life science engineering, chemistry, computer engineering, computer science, electrical engineering, environmental sciences, forensic science, mathematical sciences, mechanical engineering, pre-engineering/undeclared engineering, physics, science. Information systems is a VCU STEM major but does not admit students in their freshman year. Transfer students may declare information systems, but no LSAMP students in the HSTP have majored in information systems.

[19]The NSF defines historically underrepresented racial and ethnic minorities in STEM as African Americans (or Black), Alaska Natives, Hispanic Americans (or Latinx), Native Americans, Native Hawaiians, and Native Pacific Islanders.

**TABLE 3 |** Fall Academic Success Seminar topics.

| | |
|---|---|
| Week 1 | Welcome, introductions, syllabus instructions, review student schedules |
| Week 2 | Reflection on the summer |
| Week 3 | Let me learn assessment |
| Week 4 | How do I study for…. given how I learn ….? |
| Week 5 | Discovering your core values and VIA strengths assessment |
| Week 6 | Explore resilience and mindfulness or exploring your strengths |
| Week 7 | Mid-semester updates and check-in |
| Week 8 | Unconscious bias or social identity[a] |
| Week 9 | Who are your "FAV 5"?–building your personal advisory board |
| Week 10 | People of color in leadership or reflection on AALANAI excellence[a] |
| Week 11 | Resume workshop and interacting with company representatives or industry panel[a] |
| Week 12 | Interviews-charting your course or financial planning |
| Week 13 | Undergraduate research or graduate student panel[a] |
| Week 14 | End of semester check-in and celebration |

[a]*Topics not covered in the fall Academic Success Seminar are covered in the spring Career Readiness Series.*

**TABLE 4 |** Focus group questions.

1. From where does your confidence in completing your degree at Virginia Commonwealth University in your current STEM discipline come?
2. What types of experiences have led you to your current academic and career goals?
3. How have your experiences in the summer transition program influenced your current academic and career goals and your confidence in graduating from VCU?
4. What role if any do you feel the summer transition program has played in you becoming engaged in scholarly or academic pursuits including conducting research, attending office hours, supplemental instruction, academic advising, professional development, study groups, etc.?
5. What makes a good student in STEM and what types of things do successful STEM students do?
6. Did participation in the summer transition program provide you with information about these "academic norms" and do you think participation in the summer transition program helped you academically; for example, an increased GPA?
7. How has the summer transition program influenced your integration into the VCU community socially?

who have graduated ($n$ = 61), 59% ($n$ = 36) graduated with a degree in a STEM discipline. It is worth noting that several HSTP students declare a STEM major when entering VCU because of their interest in pursuing a career in a healthcare related field, however, once our students come to VCU they learn of other majors, such as nursing, clinical radiation sciences, or health, physical education, and exercise science which will allow them to pursue their career aspirations, but with a STEMH degree. Thus, if we consider students who graduated with a STEMH degree (STEM plus health field), then the graduation rate increases to 70.5% ($n$ = 43) Overall, the graduation rates for students in the HSTP exceeded the university graduation rates for all AALANAI students (**Table 5**). Likewise, HSTP students persisted at higher rates when compared to the VCU AALANAI student population, with the exception of the HSTP 2018 class. Seven students from the HSTP 2018 cohort did not return to VCU the fall semester of 2020. These students were in good academic standing. While this attrition rate is higher than the university average, we hypothesize that many of the students did not return because of COVID-19 restrictions and the new modality with which many of their STEM courses and laboratories were being offered. We are following up with these students to inquire about their reasons for not returning to VCU.

Student performance in their first mathematics class and chemistry class was also tracked. Students who mastered more than 60% of the topics in the ALEKS mathematics course had an increased likelihood of earning a grade of "A" or "B" in their first mathematics class (**Figure 4**). Of the HSTP students who enrolled in a mathematics class in their first year ($n$ = 199), the majority of HSTP students enrolled in either precalculus or calculus ($n$ = 143). However, HSTP students also enrolled in College Algebra with Applications, Calculus II, Differential Equations, Statistics, or no math at all ($n$ = 2).

Students who mastered more than 60% of the topics in the ALEKS chemistry courses had an increased likelihood of earning a grade of "B" or better in their first chemistry class (**Figure 5**). The majority of HSTP students enrolled in Chemistry 101. Chemistry is not required for all STEM majors thus there are fewer students who enrolled in chemistry during their first year. Furthermore, the Department of Chemistry instituted more stringent prerequisite requirements for students to enroll in General Chemistry. Thus, our data sample for **Figure 5** has only 59 students in comparison to the mathematics enrollment numbers.

However, findings thus far indicate that students within the program who did well with the ALEKS courses do better in their mathematics and chemistry courses than the students in the program who did not do well with the ALEKS courses.

## Hybrid Summer Transition Program Evaluations–Exit Surveys

Students were given exit surveys at the conclusion of the HSTP to help program directors better understand participants'

**TABLE 5 |** Retention and graduation data for HSTP students compared to all AALANAI VCU students.

| | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| HSTP student data | | | | | | |
| # of HSTP participants | 22 | 41 | 49 | 26 | 30 | 33 |
| STEM retained | 40.91% | 43.9% | 44.9% | 65.4% | 30%[a] | 63.6% |
| Persisting | 4.5% | 14.6% | 30.6% | 73.1% | 63.3% | 84.9% |
| Graduated | 72.7% | 56.1% | 40.8% | 7.6% | – | – |
| VCU AALANAI student data | | | | | | |
| Persisting | 2.8% | 8.9% | 24.6% | 67.7% | 71.3% | 81.1% |
| Graduated | 63.5% | 57.8% | 40.0% | 3.1% | | |

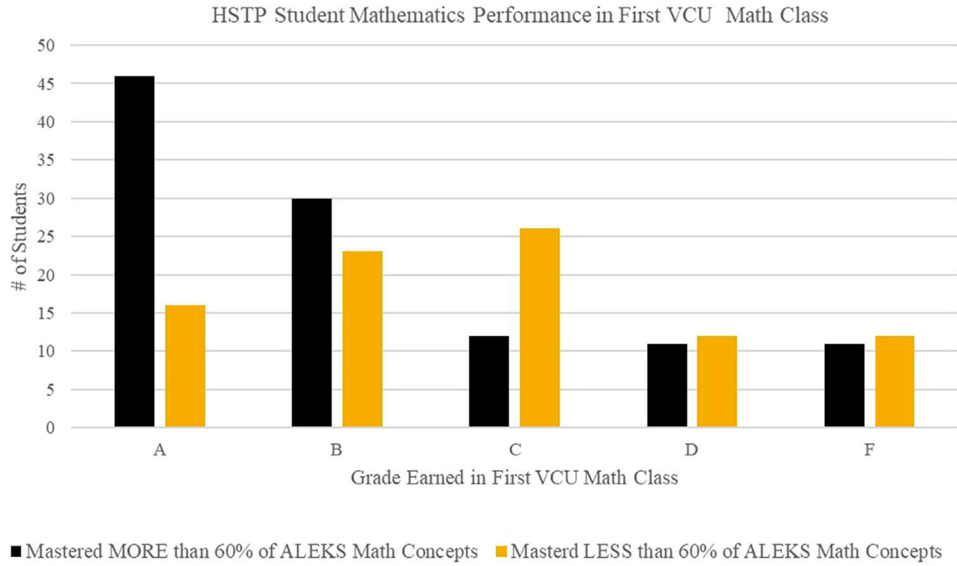



**FIGURE 4 |** HSTP student performance in first mathematics class taken.

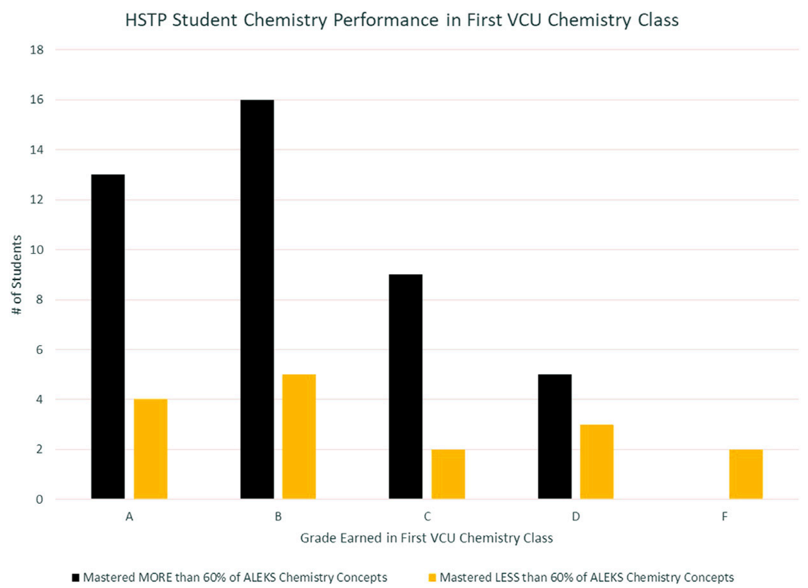



**FIGURE 5 |** HSTP student performance in General Chemistry course.

**TABLE 6 |** Exit Survey Questions.

Questions that pertained to student preparation for first year courses.

1. I feel the online portion of the summer transition program was effective in preparing me for my college courses in MATHEMATICS.
2. I feel the online portion of the summer transition program was effective in preparing me for my college courses in CHEMISTRY.
3. I was self-motivated to learn the course material throughout the online portion of the program.

Questions that pertained to overall experience

1. What activity did you enjoy the most during the week on campus? Why?
2. What activity did you enjoy the least during the week on campus? Why?
3. Was there an activity or speaker you wish had been included during the on-campus program? If yes, please explain what you would have liked to have seen incorporated and why?

perception of the impact of the HSTP on their academic preparation, their evaluation of various activities, and how successful the HSTP was in achieving the desired outcomes. In the exit survey, students were asked to rate statements given in **Table 6** using the following scale; strongly agree, agree, disagree, and strongly disagree. Nearly 90% of the students who participated in the survey reported either strongly agreeing or agreeing that the online portion helped prepare them for their first-year mathematics course. Additionally, more than 90% of the students who completed the survey reported feeling that the online portion prepared them for their first-year chemistry course. Similarly, approximately 90% of the students reported feeling motivated to complete the ALEKS curriculum. In addition to the scaled questions students were asked free response questions to allow an opportunity for them to elaborate on the specific activities and in what aspect they were affected. **Table 6** shows the open-ended questions.

Among all the program activities the ropes course/team building was the most favored among the students. Students who cited the experience identified the activity as an effective platform to build bonds, trust and get to know one another.

> "I enjoyed being able to connect to people I did not even know or would not have even talked to before the event."

During the evaluation of survey responses to the first free response question students also reflected favorably on the study skills courses. Many were able to draw direct connections between the course topics and the current academic journey.

> "I enjoyed the Study Skills class and the field trips the most. This is because during the study skills class we learned so much about accepting that we will face failure in school, however, we shouldn't let it overcome us. We also learned the importance of taking time out for yourself despite all the craziness of being a student. I enjoyed the field trips because they allowed me to explore other professions that I considered."

> "Listening to the study skills lecture because it was very relevant to me and will be relevant in my life in the future, both academically and not."

The collaborative project-based learning environment was the final program activity to be heavily noted by the students as a favorable experience. Students openly discussed frustrations in the project scope and time commitment but enjoyed sharing their ideas with their peers and expert faculty members.

In contrast the students cited the lab tours and presentations as the activities least favored. While some categorized the formal presentations as informative, many described the scope as limited. Students in the program came from several different STEM disciplines, thus it was important to have presentations from across the various STEM fields. For example, the tour of the Virginia Department of Forensic Science may have been interesting to the several forensic science majors and less enjoyable for the electrical engineering students. In contrast, the tour of the Wright Virginia Microelectronics Center might be more enjoyable to the physics and engineering majors and less so for the math and biology majors. The presentations prepared were largely geared to the engineering discipline, including the methodology with the design project. However, students desired increased representation in other STEM disciplines, college affinity groups and administrative personnel. Additionally, students believed that the dense schedule prevented them from completing additional tasks within their ALEKs programming.

## Focus Groups and Interview Findings

Overall, whether in focus groups or interviews, when participants were asked about how the HSTP specifically influenced their current academic career goals participants frequently referred to the peer support system the program provides. They also noted the significance of seeing people from similar backgrounds who shared similar passions. Most of the respondents noted that the HSTP gave them confidence and decreased anxiety in approaching professors. Multiple students also discussed how participation in the HSTP decreased their anxiety at the start of the school year, since they were already familiar with the campus and had a network of friends once they returned for the fall semester. Findings from the focus groups provide compelling evidence that participants in the hybrid summer transition program experience a caring educational environment (Gilligan, 1982; Noddings, 1984; Noddings, 2013; Lane, 2016) which is fostered and strengthened as they continue with LSAMP.

In many ways the program helped them adjust to college schedule/setting, gave them people to form study groups with and overall increased their motivation to do well and finish the program. Students' comments also serve as evidence that they value their membership in the community established by the HSTP and feel a responsibility to succeed and to remain integrated into that community. The realization that many AALANAI students entering STEM disciplines do not complete their programs of study has motivated them to finish their current degrees because they do not want to be another statistic. They formed a sense of accountability to one another. Students were asked in focus groups and interviews if they felt the HSTP contributed to academic success. While the students could not definitively say the HSTP improved their academic performance, they did note the significance of being familiar with both the academic topics in their chemistry and mathematics classes, along with the behaviors and norms to which the study skills class exposed them.

The focus group findings suggest much of the HSTP's impact on student integration at VCU is related to the social networks students developed while participating in the program. This finding is supported by other studies that have documented the benefits provided by cohort-development in summer transition programs (Stolle-McAllister et al., 2011; Lane, 2016). However, the findings also suggest many HSTP participants entered the program with high levels of perceived self-esteem, high motivation, and well-formed career goals, and students provided only few examples of how participation in the HSTP helped them develop in those areas. The HSTP may be one of many tools that motivated, engaged students are able to wield to build their own local communities in which they hold valuable academic and social capital. A more comprehensive exploration of the qualitative findings from the focus groups are presented in Griggs et al. (2016) and from the interviews are presented in Griggs and James (2019), Brinkley et al. (2014).

## Design Project Challenge Evaluation

Given that the Design Project Challenge (DPC) was a unique feature introduced in 2014 with the creation of the HSTP, special focus was given to evaluating this aspect of the program in 2018. The HSTP participants from 2015 to 2018 were surveyed and asked to reflect on the impact of the DPC on their academic pursuits and on their interest in undergraduate research and product design and innovation. The invitation was sent to all HSTP participants from these cohorts ($n$ = 146). The survey had an 18% response rate ($n$ = 27). In addition, an invitation was sent to all students from the 2015–2018 HSTP cohorts to be interviewed of which 3 students volunteered to participate.

Recurring themes observed from the survey and interviews were that the DPC taught them how to develop their ideas and present their work in a professional manner. Individuals responded positively to working with other students with shared academic interests and expressed a sense of accomplishment when presenting their final project at the Closing Ceremony. One student reflected that.,

> "I feel as though it really pushed us to think and work with each other in order to achieve something."

These learning outcomes and student feedback mirror the factors identified in (Reisel et al., 2015) that outlined effective components of a successful research experience. As expected, the brief duration of the DPC does limit the ability to train students in STEM research technical skills, in agreement with Adedokun et al. (2014). However, feedback from the survey suggest that despite the limited time frame the DPC extends freshman student's awareness of the research process and product design, effective communication, and possible STEM careers. One student shared,

> "By preparation, it gave me a glimpse on how I'd be approaching my assignments and compiling research in my classes. Also, it gave me a new perspective on my strengths and weaknesses when it comes to communication skills and teamwork projects like such."

Students' motivation to continue to persevere within STEM disciplines was explored and whether exposure to research and design at the onset of college education serves as a key component of that motivation. A majority of survey respondents report that participating in the HSTP DPC, prepared them for their undergraduate discipline (**Figure 6A**). Students made the following remarks:

> "(The Design Project Challenge) definitely made me more comfortable with thinking within my discipline."
>
> "The Design Challenge introduced me to the struggles and benefits of teamwork and communication and has prepared me for later study involving partners and teams."

While all of the respondents from the 2017 HSTP reported engagement in undergraduate research or product innovation, this was not consistent across all cohorts (**Figure 6B**). Of these students, 50–100% attributed their engagement in undergraduate research to their participation in HSTP (**Figure 6C**). To probe the role of students' career aspirations in their experience within HSTP, students were asked to elaborate on their aspirations. 50–75% of survey participants stated that elements of their interests and career aspirations were included in the DPC (**Figure 6D**).

As stated earlier, a primary goal of the VA-NC Alliance is to increase and diversify the number of students that matriculate to graduate STEM programs. With this goal in mind, students were asked if participation in HSTP increased their interest in pursuing graduate degrees in STEM programs. 75–100% of survey participants reported interest in attending graduate and or professional school after participating in HSTP (**Figure 6E**). Regarding their experience in the DPC, one student expressed:

> "As a person who is interested in going into research as a profession, I think the project planning/research aspects of the challenge were most relevant to my career interests."

The DPC was able to foster a link between students' personal interests and career aspirations. In addition, the top three teams are given the opportunity to continue working on their projects throughout the school year. This offers continuation of their

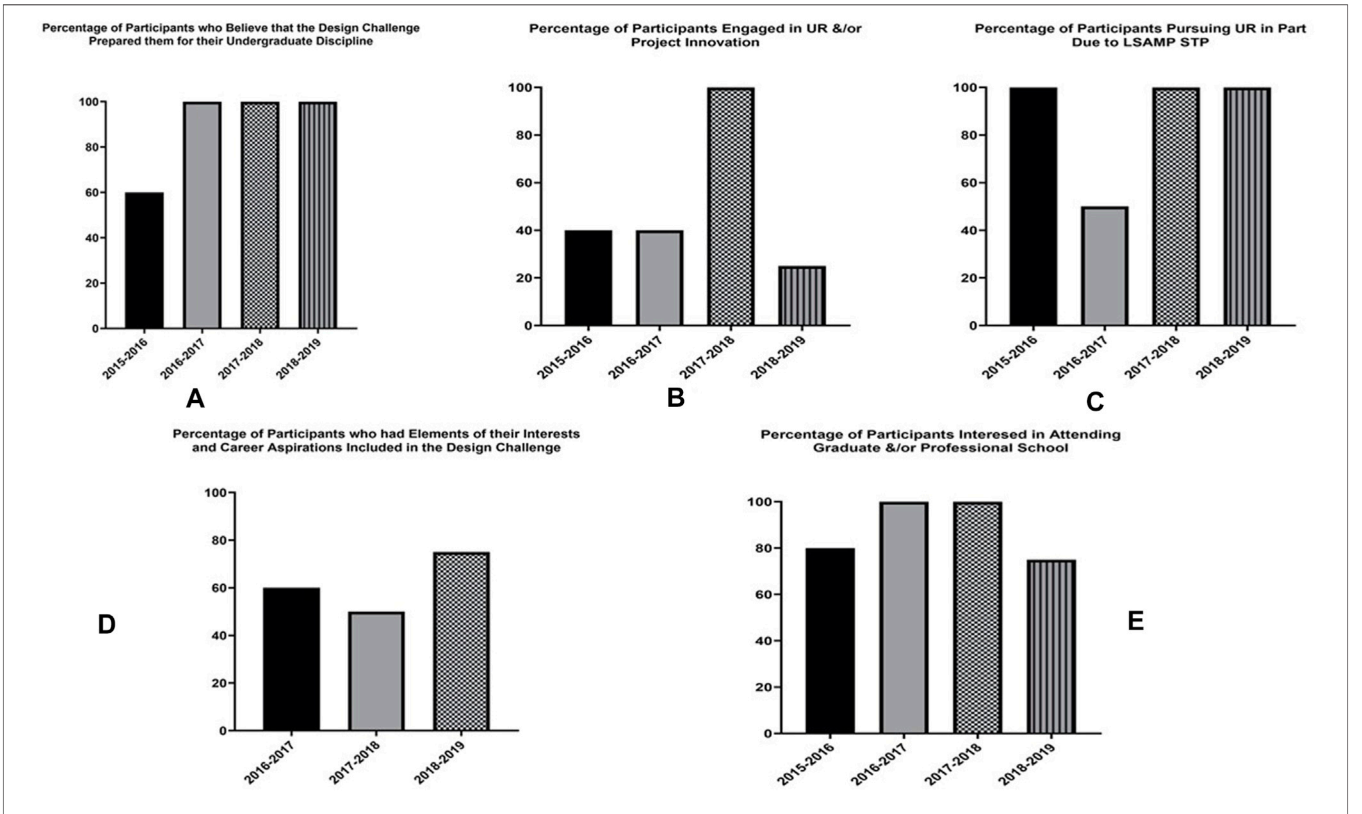



**FIGURE 6 |** Design Project Challenge Survey responses: **(A)** Percentage of survey respondents who believe the Design Challenge prepared them for their undergraduate major. **(B)** Percentage of survey respondents who participated in undergraduate research or product innovation. **(C)** Percentage of survey respondents who believe their participation in the HSTP contributed to the decision to pursue undergraduate research. **(D)** Percentage of survey respondents whose personal interest and career aspirations were reflected in aspects of the Design Challenge project. **(E)** Percentage of survey respondents whose interest in attending graduate and or professional school piqued after participating in HSTP.

training, increasing their exposure to research and design, and strengthening their interests in STEM fields.

## CONCLUSION

Results show that the HSTP which consists of a brief residential experience (to familiarize students with campus and their peers) combined with online academic support (e.g., ALEKS) is achieving its intended goals of building community among a cohort of students, orienting students to VCU, preparing students for the academic rigors of their first year in a STEM discipline at VCU, exposing students to opportunities and careers in STEM, engaging them in the VCU LSAMP program, and providing financial support. While some argue that students who participate in such programs might be highly motivated students who would already be on a successful academic trajectory, literature suggests many of these highly motivated students still need assistance in building the social, academic, and professional capital needed to be successful in STEM programs at the collegiate level (Stolle-McAllistor, 2011). Based upon the findings presented in this paper, participation in the VCU HSTP is sufficient in building this capital in AALANAI students majoring in a STEM discipline.

## LIMITATIONS

This paper presents program evaluation data and data from portions of an ongoing research study. As such there is no control group with which findings can be compared. In addition, data from focus groups and interviews are only from students who remained active in the program and voluntarily participated in the interviews and focus groups. Thus, the findings are susceptible to both selection bias and response bias and may not reflect the experiences of nonparticipants or students who dropped out of the program. As the data is collected through formative assessment tools, many of the questions reflect a method of inquiry posed to improve the program and not necessarily measure the impact of the program. Qualitative data are only from points in time in the program and were not collected annually, thus they only reflect a subset of the population of all VCU HSTP students.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the data set consist of program evaluation data and aggregate student academic performance data. Per IRB approval this data is protected. Requests to access the datasets should be directed to rhobson@vcu.edu.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Virginia Commonwealth University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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# Persistence of Underrepresented Minorities in STEM Fields: Are Summer Bridge Programs Sufficient?

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Disparities in undergraduate STEM degree completion across different racial/ethnic groups have been a topic of increasing national concern. This study investigates the long-term outcomes of a STEM intervention program designed to increase the academic preparation, achievement and persistence of under-represented minority students.In particular, this study examines the extent to which participation in a STEM intervention program can impact the long-term persistence and graduation of first-time in college under-represented minority students. Using discrete-time competing risks analysis, results demonstrated that participants of the intervention program had a lower probability of drop out and higher probability of persisting in a STEM field of study compared to non-participants of the program. Additionally, descriptive results demonstrated that participants of the STEM intervention program had higher rates of graduation in any field compared to non-participants of the program, while program participation was not a significant predictor of six-year graduation. Findings highlight the importance of early academic preparation in Calculus and total credit accumulation to student success outcomes of URM students enrolled in STEM fields. Recommendations from this study focus on early intervention efforts, particularly in the areas of mathematics, that ensure URM students are adequately prepared with the skills needed to succeed in a STEM field of study.

**Keywords: stem education, persistence, underrepresented minorities, intervention, racial differences**



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## INTRODUCTION

For years, disparities in STEM degree completion has been a topic of increasing concern among policy makers, educational leaders, and the scientific community at large. On a global scale, disparities in STEM educational achievement is a persistent and pressing issue, causing a myriad of education reform and intervention efforts to combat achievement gaps (Clark, 2014). Internationally, disparities between student performance in STEM by socio-economic status, gender, and race/ethnicity are demonstrated through several measures such as persistence and graduation rates, drop-out rates, and GPA (Clark, 2014; Heilbronner, 2014). According to the 2012 international PISA assessment, disparities in STEM achievement exist in every country in the world, with larger disparities apparent across socio-economic status (Marginson et al., 2013). In the United States a growing population of minority students and increasing racial disparities in STEM degree attainment have raised much concern over the country's ability to maintain its prominence in the fields of technology and scientific innovations (Holdern & Lander, 2010; National Academies of Science, Engineering and Medicine, 2019). The failure to build an adequately trained, diverse STEM workforce in the U.S. that mirrors its shifting demographics will undoubtedly have critical implications on the economic and scientific development of the country. (Espinosa, 2011; Foltz et al., 2014).

In the United States under-represented minority (URM) students are defined as students from Black, American Indian, Alaskan Native, Hawaiian Native, Mexican American, or Mainland Puerto Rican backgrounds (Association of American Medical Colleges, 2003). There is a robust body of evidence indicating that URM students are more likely to come from low socio-economic backgrounds and endure financial troubles during college or university (Cullinane and Leewater, 2009; Estrada et al., 2016). For undergraduate students pursuing STEM fields, research studies indicate that under-represented minority students are equally as likely to enter STEM fields as their white peers. However, wide gaps exist in the persistence rates of minority students completing these fields (Eagan et al., 2013; Lane, 2016). Recent data by the National Center of Education Statistics indicate that in the 2018/2019 academic year, 59% of Bachelor degrees in Science, Technology, Engineering, and Mathematics were awarded to white students, while only 15% were awarded to Hispanic students, and 9% to African American students (NCES, 2018). These percentages fail to reflect the growing minority population in the United States, where the Hispanic and Black population make up 18.5 and 13.4% of the nation's demographic, respectively (U.S. Census Bureau, 2019). Contributing to these wide disparities in educational achievement is the inadequate academic preparation and limited financial resources available to many URM students (Lichtenberger and George-Jackson, 2013).

Several national institutions have embarked on initiatives designed to combat the disparities in STEM educational achievement among URM students. One of these initiatives is STEM intervention programs, that focus on increasing the academic preparation of URM students in their respective fields of study (Carpi et al., 2017; Estrada et al., 2014). Studies indicate that participation in STEM intervention programs can significantly influence persistence among URM students pursuing STEM fields (Jackson and Winfield, 2014; Lee and Harmon, 2013; May and Chubin, 2003). Certain charactecteristics of STEM intervention programs are particularly helpful to increasing persistence among URM student populations, including the focus on enhancing academic and social integration among minority students (Astin and Astin, 1992; Pascarella and Terenzini, 1991; Pascarella et al., 2011). Such features not only increase the chances of minority student persistence in STEM fields, but also aid in the development of their science identity, a critical component to the motivation and persistence of URM students in STEM fields of study (Carlone and Johnson, 2007; Espinosa, 2011).

## LITERATURE REVIEW

The following sections illustrates how certain features of STEM intervention programs, particularly those of the program examined in the present study, could collectively contribute to the persistence of URM students in STEM fields. In line with previous studies surrounding STEM intervention program outcomes on URM students, such programs target disadvantaged students from low socio-economic backgrounds without the adequate academic preparation or economic means to successfully pursue a degree in a STEM field (Aulk et al., 2018; Rask, 2010). Prior research posits that, rather than a single defining feature of intervention programs that singularly affect student persistence, it is the contributing effect of several program elements discussed below that collectively promote URM persistence in STEM (Lane, 2016). To that end, it is important to disentangle ascribed (socio-demographic) and attained characteristics through intervention efforts in the discussion of URM persistence in STEM (Hu and Wolniak, 2010).

### Factors Influencing Minority STEM Persistence

Student persistence in STEM is affected by several aspects related to their pre-college academic preparation, race and ethnicity (Saw et al., 2018; Shaw and Barbuti, 2010). Importance of rigorous course taking in mathematics and science has a positive impact on STEM degree attainment (Sadler et al., 2014). High school academic preparation, specifically in math, can increase students' odds in STEM persistence (Adelman, 1999; Aulck et al., 2017; Chen, 2013). For example, Aulck et al. (2017) used maximum likelihood models to examine factors that predict student persistence in STEM. One of their study's most notable findings was the weight of success in gatekeeper math courses to student persistence in STEM, particularly during the first year of study (Aulck et al., 2017). The significance of math courses as a predictor of success in STEM has been echoed in other studies (e.g. Chen, 2013; Rask, 2010; Sadler et al., 2014; Whalen and Shelley, 2010). In a report for the National Center for Education Statistics (NCES), Chen (2013) examined a nationally representative sample of undergraduate students to uncover factors related to STEM attrition and graduation. He found that students who persisted in STEM are more likely to have taken calculus in their first year of college compared to those who fail to persist or drop out (Chen, 2013).

Furthermore, a student's precollege academic background plays a vital role in determining their persistence in a STEM field of study (Acton, 2015; Crisp et al., 2009). Acton (2015) conducted a survival analysis model analyzing the factors that influence time to graduation among undergraduate students enrolled in STEM fields. Results of the proportional hazards model indicated that higher math SAT scores increased students' hazard of persisting in STEM by 0.3%, while taking calculus in high school increased a student's hazard of graduating by 177.2% (Acton, 2015). Pre-college academic preparation is particularly crucial among disadvantaged URM populations for whom many did not receive the adequate high school training in math or STEM foundational courses that would aptly prepare them for college-level work (Chang et al., 2014; Riegle-Crumb et al., 2019; Lisberg and Woods, 2018). The achievement gaps that are already apparent prior to URM students' matriculation into college could not only impact their persistence in STEM fields, but also plays a part in negatively impacting their mindset and motivation as they begin their STEM majors (Riegle-Crumb et al., 2019; Lisberg and Woods, 2018). To that effect, one of the key characteristics of STEM intervention programs is academic preparation in mathematics. Summer bridge programs often offer students intensive instruction in foundational math and science courses to give academically under-prepared students a boost prior to beginning their STEM degree (Moreno and Muller, 1999; Duncan and Dick, 2000). Drawing upon Treisman's (1992) Mathematics' Workshop Model, the collaborative learning approaches used in mathematics courses are particularly helpful in improving the academic preparation of URM students. In addition, STEM intervention programs continue to strengthen students' academic skills in math as they move along their degree plan through supplemental instruction, workshops and faculty mentoring (Lee and Harmon, 2013; Estrada et al., 2016).

## The Role of Peer and Faculty Mentorship on Minority Student Success in STEM

Literature examining racial persistence gaps in STEM fields underscores the role of peer and faculty mentorship as key factors to URM student success (Holland et al., 2012; Leggon, 2009). For URM student populations, peer and faculty mentorship can help students feel better integrated with their academic community, and help students develop resiliency, coping and time management skills (Mondisa and McComb, 2015). For instance, Hurtado et al. (2007) examined factors that predicted minority student adjustment in STEM through their first year of study using regression analysis. Their study found that informal peer groups can facilitate student's transition into their STEM field of study, helps promote camaraderie among participants of the program and increases sense of belonging of students as they progress through their majors (Hurtado et al., 2007). Collective findings from prior research studies also point to the importance of faculty mentorship on improving academic performance of minority students in STEM courses, enhancing students' sense of academic and social integration within their academic community (Kendricks et al., 2013; Wilson et al., 2010). Kendricks et al. (2013) investigated the impact of faculty mentoring conducted as part of the Benjamin Banneker Scholar Program (BBSP), a STEM intervention program designed to increase the retention and academic success of URM students enrolled in STEM fields. Their study found that faculty mentoring was continually the factor with the strongest impact on minority students' academic performance in STEM. Additionally, findings from student survey data revealed that many faculty mentor roles exceeded the realms of academic assistance in coursework. The faculty mentor, for many minority students, represented a source of social and cultural support, provided guidance during financial and family hardships, and offered valuable internship opportunities and career guidance for students. Considering the integral role of science identity in establishing a foundation for minority student success in STEM, faculty and peer mentoring also represent two crucial components central to fostering minority students' academic integration and identification with the science community (Carlone and Johnson, 2007; Holland et al., 2012; Kendricks et al., 2013).

## Characteristics of STEM Intervention Programs

STEM intervention programs, in recent years, have been used to combat the disparities in STEM degree completion among URM student populations. Research suggests that one of the most meaningful ways in which STEM intervention programs can increase minority student success is through building their science identity (Carlone and Johnson, 2007; Chang et al., 2014; Schultz et al., 2011; Estrada et al., 2018). This aspect of intervention programs is particularly relevant to minority student populations who tend to experience less belonging to their academic communities as compared to white students (Hausmann et al., 2007). Along those lines, STEM intervention programs that focus on building URM students' sense of identification with being scientists, and promote students' sense of integration within the scientific community are more likely to have successful outcomes in terms of STEM persistence and graduation (Foltz et al., 2014; Estrada et al., 2018). Program features such as collaborative learning activities, strong faculty mentorship and advising collectively play a role in promoting minority students' sense of integration with their academic environment, as well as the motivation and confidence to pursue their academic and career goals (Carlone and Johnson, 2007; Ghee et al., 2016).

Evidence shows that STEM intervention programs provide numerous benefits in promoting students' confidence and communication skills, as well as building student's skill-set and knowledge to succeed in different STEM career pathways (Barlow and Villarejo, 2004; Ghee et al., 2016). Studies have shown the positive gains associated with participation in STEM intervention programs (Fecheimer et al., 2011; Ghee et al., 2016). For instance, Ghee et al. (2016) examined the aspects of a STEM summer enrichment program that were particularly related to persistence and success in a STEM field of study. Their results demonstrated that mentorship, collaborative study groups, and research preparation activities incorporated in the summer program increased students' research skills and self-efficacy. Financial aid also represents a major barrier towards degree completion and persistence among minority students. Intervention programs that offer financial aid to students provide relief for students by removing financial pressures, increasing student motivation to persist through their STEM degree (Eagan et al., 2010).

# PURPOSE OF THE STUDY

Given the importance of STEM intervention programs to URM persistence in STEM fields of study, and the national imperative to diversify and adequately prepare students for a successful STEM career, this quantitative study examines the extent to which participation in the University of Houston's SEP

Summer Bridge Program has an influence on student persistence and dropout rates among URM student populations. In particular, the study addresses the following research questions:

1) To what extent does participation in an undergraduate STEM intervention program have an association with six-year graduation rates, relative to their non-participating peers?
2) To what extent does participation in an undergraduate STEM intervention program Summer Bridge Program have an association with student dropout and persistence patterns over time, relative to their non-participating peers?

Findings from this study can contribute to the growing body of literature related to the persistence of minority students in STEM fields. More importantly, it can pinpoint specific areas where minority students are more likely to drop out along their educational trajectory. These results, therefore, could be extremely useful to institutional leaders and educational researchers in identifying and providing support to URM students during the time when they need it most. In addition, results from this analysis could provide valuable recommendations for building and improving STEM intervention programs in ways that could better equip URM students for a successful STEM career.

## MATERIALS AND METHODS

### Program Components

*Summer Bridge Program:* Students recruited into the SEP program initially begin a nine-week summer bridge program that focuses on strengthening student knowledge in basic STEM courses. The typical daily schedule lasts from 9 am to 3 pm, and incorporates faculty led instruction, along with peer mentorship and collaborative hands-on problem-solving sessions. Students are given a foundational pre-calculus course during the first two weeks of the program, followed by freshman calculus and chemistry courses. Additionally, students also receive training on time management and building their study skills as part of the program. The focused, hands-on approach implemented throughout the summer bridge program ensures summer bridge students are adequately prepared for their first fall semester in their respective STEM disciples. Participants of the summer bridge program receive financial assistance to cover the cost of program participation.

*Scholar Enrichment Program:* Summer bridge students transition to become participants in the Scholar Enrichment Program (SEP) at the start of each fall semester. SEP students benefit from several features designed to support student success and persistence in STEM, including scholarship aid, small peer-led learning groups, and collaborative learning groups. The SEP program also promotes network building between students and STEM alumni by hosting several career seminars and social events throughout the academic year. To also strengthen the relationship between students and their SEP community, participants in the summer program are also encouraged and recruited to work as tutors, peer facilitators and mentors as they progress through their degree.

### Data Source

This quantitative study examines transcript records from the 2013 and 2014 SEP summer bridge freshman cohort ($n$ = 102), and a matched group of non-SEP freshman students from the same cohort ($n$ = 1,459). The selection of years was made to ensure that the six-year graduation time frame could be captured in our analysis, while also providing a timely and current representation of URM graduation and STEM retention rates across SEP and non-SEP participants. The matched group of students was restricted to students enrolled in STEM fields of study from the three major colleges of Natural Sciences and Mathematics, Technology, or Engineering. Student transcript records used in this analysis offered in-depth insight into the academic progress of students along their STEM educational trajectory. Specifically, data analyzed in this study included a breadth of indicators regarding student demographics, by semester GPA, course taking patterns, and graduation data. Such detailed student information allowed this study to track students across time and analyze patterns of persistence and drop-out among SEP summer bridge participants and their non-SEP counterparts.

## DATA ANALYSIS

### Propensity Score Analysis

To control for selection bias, the first phase of analysis included creating a propensity-score matched sample of students that will match SEP summer bridge students with similar STEM undergraduate students using a selection of baseline covariates (Ghazzawi et al., 2020; Rosenbaum & Rubin, 1983). To that effect, the use of propensity score analysis created treatment and control groups that were statistically similar in baseline characteristics, allowing the effect of program participation to be more accurately captured (Ashford et al., 2016). The first step of the propensity score model included the calculation of a propensity score, which is probability of group assignment (SEP or non-SEP). An examination of areas of common support was conducted to observe the balance of covariates among treatment and control groups. This was followed by a 1:1 nearest neighbor matching method within a predetermined caliper, enabling SEP students to be matched with their non-SEP peers with similar propensity scores. Selection of covariates was informed by research studies linking student socio-demographic and pre-college characteristics to persistence in STEM fields (Hurtado et al., 2007; Murphy et al., 2010; Ashford et al., 2016; Ghazzawi et al., 2020) These covariates included race, gender, age, and standardized math test scores. Descriptions and coding of baseline covariates are presented in **Table 1**.

A propensity score matched sample of an equal number of SEP summer bridge students, and matched non-SEP students was created using 1:1 nearest neighbor matching within caliper ($n$ = 194). Approximately 34% of the matched sample consisted of black students, 43% Hispanic, 10% White, and 13% Asian. **Table 2** presents descriptive statives of baseline covariates across pre and post-matched samples of treatment and control groups. Prior to the matching, the average math SAT

**TABLE 1 |** Coding for Baseline Covariates. By Dina Ghazzawi, Donna Pattison, and Catherine Horn.

| Variable | Coding |
|---|---|
| Gender | 0 male, 1 female |
| Race (black) | 0 other, 1 black |
| Race (white) | 0 other, 1 white |
| Race (hispanic) | 0 other, 1 hispanic |
| Race (asian) | 0 other, 1 asian |
| Age | Continuous |
| SAT math score | Continuous |

score of non-SEP students was higher than those of SEP students. As observed in **Table 2**, differences in post-matched average math SAT scores across treatment and control groups were reduced. In addition, the matched sample contained a more balanced distribution of students from different ethnicities across treatment and control groups.

## Impact of Program Participation on Six-Year Graduation

Following the propensity score matching procedure, a logistic regression analysis was conducted on the resulting matched dataset of SEP and non-SEP students to examine the impact of program participation on six-year graduation rates (in both STEM and non-STEM fields) after controlling for the baseline characteristics of race and pre-college academic performance. Guided by supporting literature on the importance of the Calculus course taking patterns on student graduation rates, a categorical variable indicating the time in which students took Calculus I was incorporated into the analysis as an independent variable (Chen, 2013). In addition, the academic progress variables of final cumulative GPA and total credits accumulated were added into the model to assess their effect on graduation rates.

## Discrete-Time Survival Analysis

Following this procedure, the second phase of the analysis involved discrete-time survival analysis. Discrete survival analysis was chosen as an appropriate analytic method due to its unique contributions to the field of education research where events occur in distinct periods of time. In addition, survival analysis examines the time to event occurrence, using predictors that can be both time-varying and time-invariant, lending flexibility and depth to models. Finally, inherent in survival analysis models is the concept that the effect of a predictor on the probability of event occurrence can change over time (Singer and Willet, 1993). Given the unique characteristics that are directly applicable to the research questions in this study, discrete survival analysis was chosen as the most appropriate methodological approach.

Guided by Singer and Willet (2003), the dataset was constructed as a person-period dataset, where each record represented a particular semester in which a student was enrolled in a STEM field of study. Students were in one of two states, the treatment group (TREAT = 1), which included students enrolled in the SEP summer bridge program, and those in the control group (TREAT = 0). Students were tracked from their first entering semester in the program (freshman year) where time = 0. The data was right-censored, meaning that not all students graduated within the time frame captured in the data.

Discrete-time survival analysis was employed in two ways in this study. Firstly, to examine the survival and hazard estimates of persistence in a STEM field across the matched sample of SEP and non-SEP students. Secondly, competing risk discrete-time event history analysis was conducted to examine the differences in the probability of dropping out of a STEM field of study between participants of the SEP summer bridge program and those not enrolled in the program. The use of competing risk analysis was necessary in examining drop out behavior among students given the probability of persistence in a STEM field, as both events are

**TABLE 2 |** Descriptive Statistics- Full Sample of SEP Bridge and Non-SEP Bridge Students. By Dina Ghazzawi, Donna Pattison, and Catherine Horn.

| | Pre matched | | | | Post-matched | | | |
|---|---|---|---|---|---|---|---|---|
| | SEP (*N* = 102) | | Non-SEP (*N* = 1,459) | | SEP (*N* = 97) | | Non-SEP (*N* = 97) | |
| | *N* | % | *N* | % | *N* | % | *N* | % |
| Gender | | | | | | | | |
| Female | 42 | 41 | 622 | 43 | 39 | 40 | 39 | 40 |
| Male | 60 | 59 | 837 | 57 | 58 | 60 | 58 | 60 |
| Race | | | | | | | | |
| Asian | 13 | 13 | 570 | 39 | 12 | 13 | 12 | 12 |
| Black | 33 | 33 | 112 | 8 | 32 | 34 | 32 | 33 |
| Hispanic | 43 | 43 | 400 | 27 | 41 | 44 | 41 | 42 |
| Multi | 0 | 0 | 50 | 3 | 0 | 0 | 2 | 2 |
| Pacific islander | 0 | 0 | 3 | 0.21 | 0 | 0 | 0 | 0 |
| Unknown | 0 | 0 | 13 | 0.89 | 0 | 0 | 1 | 1 |
| White | 10 | 10 | 310 | 21 | 9 | 9 | 9 | 9 |
| Age | 17.95 | M | 17.96 | M | 17.95 | M | 17.97 | |
| | 0.355 | SD | 0.436 | SD | 0.364 | SD | 0.305 | |
| Math SAT scores | 606.08 | M | 624.70 | M | 606.08 | M | 606.70 | |
| | 60.70 | SD | 70.90 | SD | 60.70 | SD | 66.23 | |

**TABLE 3 |** Coding for Independent Variables. By Dina Ghazzawi, Donna Pattison, and Catherine Horn.

| Variable | Coding |
|---|---|
| Program participation | 0 Non-SEP (control), 1 SEP (treatment) |
| Calculus I year taken | 0: Not taken, 1: Taken in first year, 2: Taken in second year or after |
| Cumulative GPA | Continuous |
| Total credits accumulated | Continuous |

mutually exclusive as students who persist in a STEM field are no longer at risk of dropping out and vice versa. The use of competing risks analysis, rather than traditional logistic regression models, enabled the study to account for timing of student dropout, and was not bound by the statistical assumptions of standard logistic regression models. To that effect, this study utilizes a competing risks model to analyze time to dropout as a function of program participation and academic factors, while simultaneously taking into account the competing risk of persisting in STEM.

## Dependent Variables

To examine the impact of program participation on six-year graduation across SEP summer bridge participants and their non-SEP peers, the dependent variable used was dichotomous, coded 0 if a student did not graduate in any field (both STEM and non-STEM) and 1 if a student graduated in a given semester.

To examine the impact of program participation on drop out, with persistence in STEM as a competing event, the dependent variable used was a categorical variable with three values, measuring the probability staying enrolled in university regardless of field, coded as 0; dropping out, coded as 1, and finally persisting in a STEM field of study, coded as 2. Power calculations were conducted to ensure the sufficiency of observations and sample size for discrete-time survival analysis. Results showed that a sample size of 72 yielded 80% power, ensuring that our sample size was adequate for proceeding with the analysis.

## Independent Variables

The first stage of the analysis matched SEP students with similar non-SEP students according to baseline characteristics of race, age, and SAT Math scores that reduce the likelihood of bias and enable program participation effects to be adequately captured (Haeger and Fresquez, 2016). Given the literature on the importance of academic progress variables, such as cumulative GPA, Calculus course taking patterns and credit accumulation on the persistence and graduation of students in a STEM field, these variables were included in the logistic regression and competing risks model (Acton, 2015; Chen, 2013; Hurtado et al., 2010). To account for the over-estimation of effects involved with non-standardized continuous variables, the variable of Cumulative GPA was mean centered supported by research studies that suggest using standardizing approaches or categorizing of continuous predictors to overcome the problem of the over-estimation of odds ratios (e.g., Ottenbacher et al., 2004) studies suggest that statistical significance or insignificance remains regardless of the method used (Nick and Campbell, 2007). Summary statistics of Cumulative GPA yielded a mean of 2.82 and standard deviation of 0.81.

# RESULTS

## Descriptive Statistics

For the 97 students in the control sample of non-SEP summer bridge students, 55 students graduated within the study time period (approximately 57%). For the 97 students in the SEP-summer bridge program, 66 students (68%) graduated within the study time period.

**Table 4** presents the total percentage of students graduating in any field, dropping out or persisting in a STEM field of study. Chi-square tests of significance showed no significant differences between the proportion of students graduated, persisting, or dropping out of their respective STEM majors across treatment and control groups.

## Logistic Regression Predicting Six-Year Graduation

**Table 5** presents the results of the logistic regression model predicting six-year graduation rates across SEP and non-SEP students. The pseudo-R squared indicated that the variables in the model explained 71% of the variation in graduation. The model indicates that participation in the SEP summer bridge program was not a significant predictor of six-year graduation after controlling for baseline characteristics. On the other hand, taking Calculus I in the first year of university was a significant predictor of graduation in six years. Students who took Calculus I in their first year of college were 1.68 times more likely to graduate in six years compared to students who did not take Calculus I at all.

Additionally, after centering, final cumulative GPA was a strong significant predictor of six-year graduation. Students were 2.99 times more likely to graduate with each point increase in final cumulative GPA. Finally, total credits accumulated was also a significant predictor of six-year graduation, raising student odds of graduating by 1.10 times with higher accumulated credits.

## Discrete-Time Survival Analysis

**Table 6** illustrates the Life Table showing the hazard and survival functions of students persisting in a STEM field of study within the 6-years study period. **Table 4** indicates that non-SEP students have a greater hazard or chance of persisting in STEM between their 9th and 10th semester (48.8%), compared to SEP summer bridge students who have a greater chance of persisting in STEM by the end of their study period (between semesters 12 and 13). The chances of students persisting in STEM increased as students remained enrolled in the program, for both SEP and non-SEP students. For instance, between their 6th and 7th semesters of

**TABLE 4 |** Descriptive Statistics: Graduation, STEM Persistence, and Drop-out. By Dina Ghazzawi, Donna Pattison, and Catherine Horn.

| Variable | Treatment (SEP) | Control (Non-SEP) | *p*-value |
|---|---|---|---|
| Persistence in STEM | 58 | 45 | 0.085 |
| Graduation (any field) | 68 | 57 | 0.103 |
| Drop out | 32 | 43 | 0.103 |

**TABLE 5 |** Logistic Regression Examining Graduation in Six-years. By Dina Ghazzawi, Donna Pattison, and Catherine Horn.

| Variable | Odds ratio | SE | 95% Confidence interval | |
|---|---|---|---|---|
| Program participation | 0.25 | 0.63 | −0.99 | 1.48 |
| Calculus I time taken (reference: never taken) | – | – | – | – |
| First year | 1.68* | 0.78 | 0.15 | 3.21 |
| Second year or after | 1.15 | 1.46 | −1.71 | 4.02 |
| Cumulative GPA | 2.99** | 0.80 | 1.41 | 4.56 |
| Total credits accumulated | 0.09** | 0.02 | 1.06 | 0.13 |

*−2 log likelihood = −37.04.*
*Pseudo R squared = 0.71.*

study, the 66 non-SEP students that remained enrolled in their STEM field of study had approximately 1.5% hazard, or chance of persisting. By the end of the study period (12th semester), their chances of persisting increased to approximately 33%. SEP students had approximately a 4% chance of persisting in STEM between their 6th and 7th semesters, which increased to 66.7% by the end of the study period.

## Competing Risks Analysis

To examine drop out behavior among students given the probability of persistence in a STEM field, a competing risks discrete-time analysis was conducted as both events are mutually exclusive as students who persist in a STEM field are no longer at risk of dropping out and vice versa. **Figure 1** displays the cumulative incidence function indicating the probability of drop-out prior to the end of the study time-frame (12 semesters), across treatment (SEP) and control (Non-SEP groups). The cumulative incidence function indicates that the probability of drop-out among both treatment and control groups is low during the first five semesters of study. At the 10th semester, the probability of drop-out for students in the SEP summer bridge program is 5%, compared to 8% for non-SEP students. The graph also indicates a reduced incidence of drop-out among SEP students compared to non-SEP students due to the reduced risk among SEP students and an increased risk of persistence (the competing event). By the 12th semester of study, non-SEP students had a 12% probability of drop out, whereas SEP students had a 7.5% chance of dropping out prior to the 12th semester. With time, there is an increase in the disparity of cumulative incidence between SEP and non-SEP students.

**Table 7** presents the results of the competing-risks regression for the cumulative incidence of dropping out during the 12 study semesters of study, using the variables of program participation, time in which Calculus I was taken, cumulative GPA, and total credit hours accumulated. Persistence in a STEM field was treated as a competing event. When taking into account the odds of persisting in a STEM field of study, the results of the competing-risks regression model indicate that SEP summer bridge students are less likely to drop out and more likely to persist in STEM. This is evident from the significant sub-hazard ratios of dropout for SEP summer bridge students that are 54.1% of those ratios for non-SEP summer bridge students ($p < 0.05$). Additionally, the total number of credits accumulated was associated with a reduced incidence of drop out among students, after controlling for program participation effects. Students with a higher number of accumulated total credits were less likely to drop out and had an increased likelihood to persist in their respective STEM field of study ($p < 0.005$). Final cumulative GPA and timing of Calculus I course taking were not significantly related to drop-out among students in STEM fields.

# DISCUSSION

The preliminary results of this study demonstrate the effectiveness of STEM intervention programs at increasing graduation rates among participants. In summary, the results of the study demonstrate that a higher percentage of SEP participants (68%) graduated in any field compared to non-SEP participants (57%). Findings also showed that taking Calculus I in the first year of college, as well as the total number of credits accumulated, were significant predictors of six-year graduation. In addition, descriptive results indicated that a lower drop-out rate and higher persistence rate of SEP summer bridge participants, compared to their non-SEP peers. These findings support previous studies that found higher rates of persistence and graduation among participants of STEM intervention programs (Estrada et al., 2016; Lee and Harmon, 2013). Furthermore, these results provide an unbiased, robust reflection of program effects on student success measures, as propensity score matching accounts for baseline covariates that could influence results (Haeger and Fresquez, 2016).

**TABLE 6 |** Life Table Summarizing Time to Graduation in a STEM field across Treatment and Control Groups. By Dina Ghazzawi, Donna Pattison, and Catherine Horn.

| Period | Time interval | Students at beginning period | Students graduated | Students censored at end of period | Hazard function | Survival function |
|---|---|---|---|---|---|---|
| Treat = 0 | | | | | | |
| 0 | (0,1] | 97 | 0 | 2 | 0 | 1 |
| 1 | (1,2) | 95 | 0 | 7 | 0 | 1 |
| 2 | (2.3) | 88 | 0 | 3 | 0 | 1 |
| 3 | (3,4) | 85 | 1 | 8 | 0.0124 | 0.9877 |
| 4 | (4,5) | 76 | 0 | 2 | 0 | 0.9877 |
| 5 | (5,6) | 74 | 3 | 5 | 0.0429 | 0.9462 |
| 6 | (6,7) | 66 | 1 | 1 | 0.0154 | 0.6187 |
| 7 | (7,8] | 64 | 21 | 3 | 0.4038 | 0.6187 |
| 8 | (8,9) | 40 | 8 | 3 | 0.2319 | 0.4901 |
| 9 | (9,10) | 29 | 11 | 2 | 0.4889 | 0.2976 |
| 10 | (10,11) | 16 | 3 | 3 | 0.2308 | 0.2360 |
| 11 | (11,12) | 10 | 2 | 3 | 0.2667 | 0.1805 |
| 12 | (12,13) | 5 | 1 | 3 | 0.3333 | 0.1289 |
| Treat = 1 | | | | | | |
| 0 | (0,1) | 97 | 0 | 3 | 0 | 1 |
| 1 | (1,2) | 94 | 0 | 5 | 0 | 1 |
| 2 | (2,3) | 89 | 0 | 6 | 0 | 1 |
| 3 | (3,4) | 83 | 0 | 4 | 0 | 1 |
| 4 | (4,5) | 79 | 0 | 2 | 0 | 1 |
| 5 | (5,6) | 77 | 0 | 2 | 0 | 1 |
| 6 | (6,7) | 75 | 3 | 1 | 0.0411 | 0.9597 |
| 7 | (7,8) | 71 | 24 | 7 | 0.4324 | 0.6185 |
| 8 | (8,9) | 40 | 9 | 1 | 0.2571 | 0.4776 |
| 9 | (9,10) | 30 | 11 | 1 | 0.4583 | 0.2995 |
| 10 | (10,11) | 18 | 4 | 2 | 0.2667 | 0.2290 |
| 11 | (11,12) | 12 | 4 | 2 | 0.4444 | 0.1457 |
| 12 | (12,13) | 6 | 3 | 0 | 0.6667 | 0.0729 |

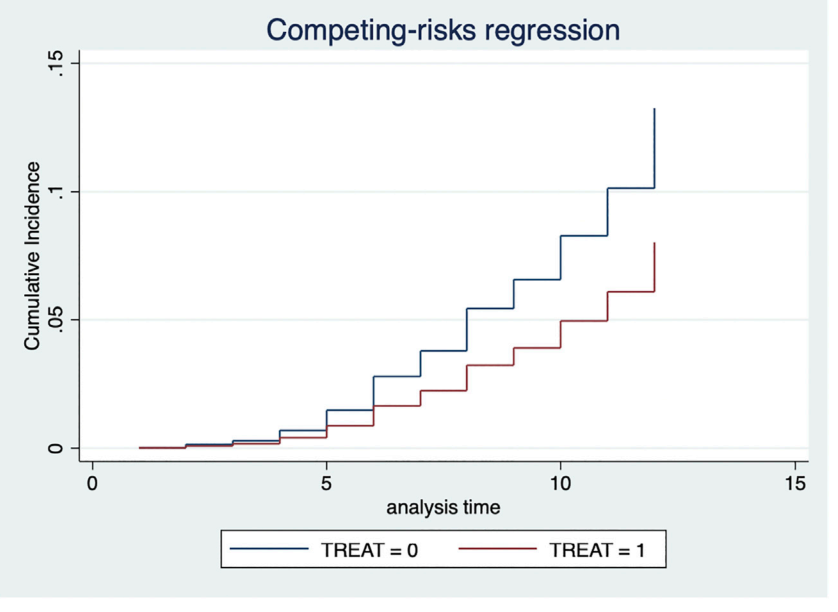


**FIGURE 1 |** Cumulative Incidence Functions Across Treatment and Control Groups. By Dina Ghazzawi, Donna Pattison, and Catherine Horn.

**TABLE 7 |** Competing-Risks Analysis: Program Participation. By Dina Ghazzawi, Donna Pattison, and Catherine Horn.

| Variable | Sub hazard ratios | SE | 95% Confidence interval | |
|---|---|---|---|---|
| Program participation | 0.541* | 0.129 | 0.337 | 0.866 |
| Calculus I year taken (reference: Never taken) | – | – | – | – |
| First year | 1.04 | 0.321 | 0.567 | 1.90 |
| Second year | 0.97 | 0.331 | 0.503 | 1.90 |
| Cumulative GPA | 0.992 | 0.216 | 0.647 | 1.52 |
| Total credits accumulated | 0.952** | 0.005 | 0.941 | 0.963 |

*Log Pseudolikelihood = −223.31.*
*Wald chi2 = 209.30.*

Results of the logistic regression analysis indicated that, after accounting for pre-college and socio-demographic variables, program participation did not significantly impact six-year graduation. However, results do demonstrate that taking Calculus I in the first year was a strong predictor of six-year graduation. Students who took Calculus I in their first year of college were 5.36 times more likely to graduate compared to those students who never take Calculus. The importance of math, and the timing of course taking in particular, is well-documented in the literature (Chen et al., 2013; Sadler, 2014; Acton, 2015; Aulck et al., 2017). One of the requirements of the SEP summer bridge program is Calculus I in the first year, as well as giving students ample preparation in mathematics during their nine-week summer bridge program. The academic preparation in math provided by the SEP summer bridge program gives greater context to the results of this study. Despite program participation not being a significant predictor of six-year graduation, the strong academic preparation in math that characterizes the SEP summer bridge program is a strong predictor of graduation. This aspect of the results provides evidence of one of the most beneficial features of the program that significantly impacts student success.

Results of the competing risks discrete-time analysis indicated that SEP summer bridge students had a lower cumulative incidence rate of drop-out compared to non-SEP students, and a higher risk of persisting in STEM, supporting prior findings (Ghee et al., 2016; Fechheimer et al., 2011). These findings contribute to a growing body of literature concerning the significant role of STEM intervention programs in reducing drop-out and increasing persistence among URM populations in several ways. Firstly, the robust and flexible implementation of competing risks regression enabled the study to capture the risk of dropout across SEP and non-SEP summer bridge students while simultaneously taking account the risk of persisting in STEM. Secondly, our results indicate that, across time, the disparity in dropout rates between SEP summer bridge and non-SEP students increases. Several studies support the benefits of collaborative learning approaches, particularly through mentorship and course-based practice, on increasing the retention, academic achievement, motivation and engagement of students in STEM fields (Lewis, 2011; Shields et al., 2012; Smith et al., 2014). Furthermore, there is strong evidence that the collaborative approaches used by STEM intervention programs such as SEP are particularly helpful in reducing achievement gaps for low-income URM students, due to the contributing effect of academic support, faculty mentorship, and sense of belonging and community offered through this mode of learning (Eddy and Hogan, 2014; Loui and Robbins, 2008; Reisel et al., 2014). These aspects of academic support are particularly beneficial in promoting URM student persistence in STEM according to collective research students (Carlone and Johnson, 2007; Estrada et al., 2018; Ghee et al., 2016).

The number of total credit hours accumulated was also significantly associated with a lower risk of dropout and a higher risk of persistence, supporting prior studies that indicate the significance of credit hours to student retention in STEM fields (Mau, 2016). The number of total credit hours is also indicative of the time spent in the program of study, demonstrating that as students' progress through their respective STEM majors they accumulate more credit hours and are at a higher risk of persisting in STEM. Since SEP summer bridge students are at a lower risk of dropping out and persist at higher rates, increasing total credit hours is a crucial component of persistence.

Despite the strong evidence demonstrating achievement gaps across race in STEM degree persistence, few studies address ways to overcome this persistent problem (Mutegi, 2013). Findings from this study present a longitudinal view of the outcomes associated with participation in an intervention programs, contributing to the extant literature by addressing the key elements that could significantly increase URM students' odds of persisting in their STEM degree. Results support continuous calls for early intervention, particularly in the areas of mathematics, which are in line with previous studies highlighting the integral role of advancing URM students' academic preparation in math in increasing STEM degree persistence (Chang et al., 2014; Lisberg and Woods, 2018; Riegle-Crumb et al., 2019).

## LIMITATIONS

Findings from this study are limited to the outcomes of a single STEM intervention from one institution, therefore results may not apply to students from different geographic areas or different types of programs. Furthermore, although discrete-time survival analysis, as well as competing risks analysis, is a robust methodological technique for tracking students' educational trajectories, it does not take into account students who may have dropped out and another university.

## CONCLUSION

Recommendations from this study underscore the importance of early STEM intervention practices, particularly academic preparation in the areas of mathematics, that enable minority student populations to be equipped with the necessary knowledge and tools to succeed in their STEM field of study. Given the strong empirical evidence supporting the significance of early academic preparation in math to minority student persistence in STEM, earlier interventions TO recruit rather than ARE and prepare URM students to enter and succeed in the STEM workforce is vital (Mau, 2016). Findings from this study underscore the importance of early preparation in math as one of the most significant factors in increasing graduation rates, emphasizing the role of mathematics preparation as an essential basis for establishing minority students' science identity and integration into their scientific community (Carlone and Johnson, 2007; Estrada et al., 2018). These findings support prior literature that highlight the importance of early intervention efforts at laying the groundwork for URM students to develop the academic skills, resiliency, and motivation to succeed in an increasingly challenging academic environment (Lisberg & Woods, 2017; Ballen et al., 2020; Yeager et al., 2016). Given these findings, further work is needed to disentangle the role of specific intervention efforts such as faculty and peer advising, and collaborative learning relative to the early exposure of key academic content on its own to uncover in which ways they precisely influence student success factors. Such information could provide valuable recommendations to program administrators on how to improve and modify program components in ways that are particularly helpful to URM populations and address their specific challenges. Specifically, future work might explore the relative amount of influence varying degrees of exposure to elements of a comprehensive intervention may have in order to make increasingly informed resource investment decisions toward outcomes of interest.

Furthermore, our results provide a nuanced perspective on progress towards degree completion that involves placing more focus on continuity rather than degree completion within a specific timeframe. For URM student populations with significant financial barriers and family responsibilities, finishing a degree plan within a classic four or six-year time-frame may not be achievable. What our results suggest is that continuity for these students, along with the right intervention and academic support, is important and leads to higher persistence rates in STEM and lower drop-out rates among URM students. Ultimately, these findings point to the need for more nuanced work in how we think of and define persistence for student populations. While this study does take into account graduation within a pre-defined six-year period, our results indicate that total credit hours accumulated was strongly associated with a lower rate of drop-out and a higher rate of persistence among students. Future work needs to go beyond the standard 4- and 6-years guidelines and examine persistence and completion out to the 8-years mark. These studies need to be also be tied to surveys documenting students financial and family situations in tandem with their persistence and completion. Setting realistic, achievable goals balanced with work/life issues would be a better service to students than defining "success" with a 4- or 6-years expiration date. Along those lines, future work should further examine the role of intervention efforts at increasing continuity and progress towards degree completion in a way that defines persistence in its varying degrees as it applies to URM populations.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

Findings from this study were part of an approved Institutional Review Board project.

University of Houston's Summer Bridge Scholar Enrichment Program.

The University of Houston's Summer Bridge Scholar Enrichment Program was established in 2000 through funding from the NSF Louis Stokes Alliance for Minority Participation. Primarily focused on increasing the participation of URM students in STEM fields of study, the program pays special attention to the recruitment of low-performing URM students though targeted communication with local high schools to determine eligible candidates that would benefit most from the program's features. The program's development was guided by Uri Treisman's (1992) Mathematics Workshop Model, and centers on using a collaborative and supportive peer learning process promote minority students' skills in mathematics and STEM foundational courses. The Mathematics Workshop Model is founded upon theories of URM students' sense of belonging and academic integration and emphasizes the importance of faculty mentoring and collaborative learning techniques for URM student success in STEM fields of study.[1]

## AUTHOR CONTRIBUTIONS

DG conducted the analyses for this manuscript and prepared the first draft. DP and CH made significant intellectual contributions to the development and editing of the manuscript. DP was involved in SEP operations during 2014 and 2015 and currently oversees the program. All authors approved the final version of the manuscript for publication.

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[1]For more information on how Treisman's (1992) model guided the development of the UH summer bridge program, please refer to: Ghazzawi et al., 2020, the previous paper in this series which discusses the impact of program participation on the graduation of URM students in STEM fields.

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# International Research Experiences in the Development of Minority Scientists

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Undergraduate research and international experiences are often described as high-impact educational practices beneficial for undergraduate student success and for supporting the development of science identity and intercultural competencies. While several studies have investigated the impact of undergraduate research on students from minoritized groups, fewer studies have focused on their engagement in global experiences, and fewer still have explored their engagement in international research experiences. Drawing on the theoretical frameworks of Science Identity, Social Cognitive Career Theory, and the Intercultural Competence Model, this present study explores the benefits of participating in an international research experience for minority undergraduate scientists. Using a qualitative case study methodology, we examined the evolution of students' science identity, research competencies, and intercultural competence after engaging in a three-month international research opportunity in France and Belgium. We found that after participating in international research, minority undergraduate scientists had: 1) Increased confidence in their science identity and abilities; 2) Gained and strengthened skills necessary to be a successful researcher, 3) Recognized the influence of international exposure on their growth personally and professionally, 4) Expressed how monumental this research opportunity is for all minority students to experience. Our findings suggest substantial benefits from an international research experience on the development of minority undergraduate scientists.

**Keywords: international research, science identity, intercultural competence and awareness, global experiences, minority scientists, underrepresented minorities, social cognitive career theory, high-impact educational practices**

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## INTRODUCTION

Throughout the science, technology, engineering, and mathematics (STEM) workforce in the United States, there continues to be a disparity in the participation of underrepresented minorities collectively (National Science Foundation, 2019). White and Asian Americans have representation within the science and engineering (SandE) workforce at rates higher than their representation in the U.S. population. Conversely, African Americans, Latino/a Americans, Native Americans, Alaskan Natives, and Pacific Islanders have much less representation within the S&E workforce than their representation in the U.S. population (Khan, 2020). This disparity in representation is often described as under-representation, and groups that are underrepresented as underrepresented minority or minoritized groups (URM) (Khan, 2020). Given the continued underrepresentation of these groups in

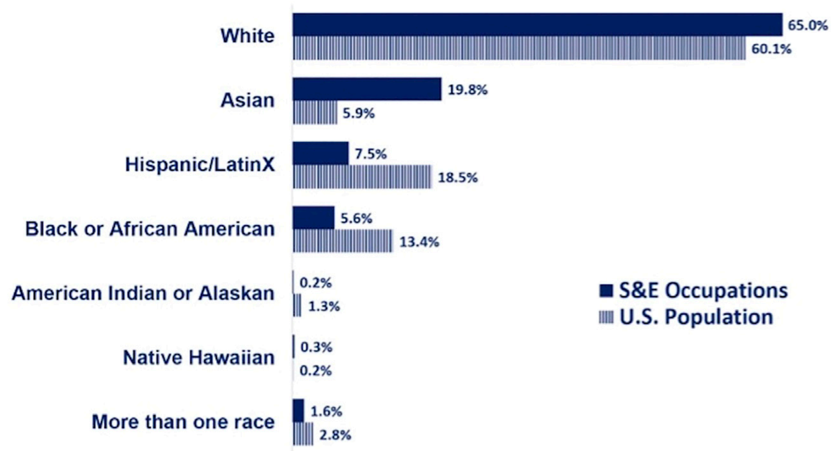


**FIGURE 1 |** Comparison of the Racial and Ethnic demographics of United States STEM Workforce and the U.S. Population.

the STEM workforce, i.e., 33% of the population vs. 13% of the STEM workforce (**Figure 1**), policymakers and educational leaders have focused on diverse approaches to address the cultivation of talent across all of our nation's citizenry.

## High-Impact Practices That Support Student Success: Undergraduate Research and International Experiences

Within the higher education landscape, leaders have advocated for and adopted several practices that research has shown to be effective for improving student success. Often described as "high-impact practices," these efforts encompass first-year seminars and experiences, common intellectual experiences, learning communities, writing-intensive courses, collaborative assignments and projects, undergraduate research, diversity/global learning, ePortfolios, service and community-based learning, internships, and capstone courses and projects (Kuh, 2008; Kuh et al., 2010).

Within the STEM disciplines at the undergraduate level, hands-on learning experiences through undergraduate research, communication or writing-intensive efforts, and internships have shown remarkable efficacy in promoting retention and success (Brownell and Swaner, 2010; DeLauder and Hollowell, 2012; Sanchez, 2012; Daniels et al., 2016; Haegar and Fresquez, 2016; National Academies of Sciences Engineering and Medicine (NASEM), 2016). As a high-impact educational practice for student retention and engagement, undergraduate research provides students with in-depth training beyond the classroom (Kuh, 2008). Specifically, engaging in undergraduate research has been proven to develop a student's self-efficacy, identity, and competencies as a researcher while exposing them to potential career pathways and graduate studies not previously considered (Egan et al., 2013; Pender et al., 2010; Russell, Hancock & Mccullough, 2007). For students from groups historically underrepresented in STEM, undergraduate research opportunities can particularly prove beneficial in developing their identity, confidence, and sense of belonging in STEM despite the lack of representation (Bangera and Brownell, 2014; Carlone and Johnson, 2007; O'Donnell et al., 2015). Consequently, several studies have shown how URMs are impacted by engaged learning through undergraduate research and similar experiential learning with significantly positive effects (Wilson et al., 2012; Daniels et al., 2016; Fakayode et al., 2016; Haegar and Fresquez, 2016; Crawford et al., 2018; Davidson et al., 2018; Fakayode et al., 2018; Wilson-Kennedy et al., 2019).

International or global experiences, another high-impact practice, have reported several positive impacts on student success (Dwyer and Peters, 2004; DeGraaf et al., 2013; Engel, 2017). One such result is the increase in student engagement and persistence in their academic programs. For example, Camesano et al. (2016) discussed the value and importance of intentional incorporation of international experiences for Ph.D. students in Biomedical Engineering to enhance their experiences. Specifically, the program's goal was to offer students "a firsthand perspective on research and translation in a global context so that they are uniquely positioned to become successful leaders in an increasingly international market" (*p.* 3). Students in this program shared how their growth personally and professionally resulted from participating in international experiences. While this program provided funding and resources for international exposure, not all students are afforded these opportunities built into their curriculum. Notably, many minority students never get the chance to travel abroad as a component of their academic studies. For example, minoritized groups who are underrepresented in STEM are also underrepresented in U.S. Study Abroad experiences (**Figure 2**), an indicator of domestic URM engagement in global experiences outside of the U.S. (Institute on International Education (IIE) and (U.S. Department of State's Bureau on Educational and Cultural Affairs, 2020). These groups have historically missed out on the types of experiences that advance intercultural competencies and leadership development.

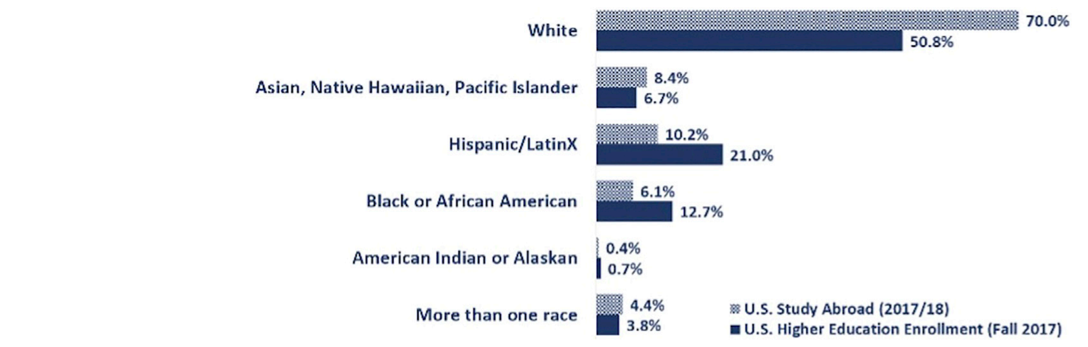


**FIGURE 2 |** Comparison of the Racial and Ethnic demographics of undergraduate students in U.S. Higher Education and those who have participated in U.S. Study Abroad.

Beyond having low participation by minority groups, international experiences have also been concentrated in non-STEM disciplines. As an example, in 2000, natural science and engineering majors (life and physical sciences, engineering, agriculture, and health) comprised only 16.6% of the share of individuals participating in U.S. Study Abroad comparable to the Arts and Humanities, Languages, Business, and Entrepreneurial Leadership, and Social Sciences comprised almost 70% of global experiences through U.S. Study Abroad. Consequently, for many years, international experiences for undergraduates have been under-utilized in the natural sciences and engineering disciplines, with very few students majoring in these fields having the opportunity to engage in even short-term immersive international experiences, much less any longer-term experiences. Notably, as the number of students participating in global experiences has grown, from 154,000 students in 2000 to 341,000 in 2017, so has the share of STEM students (Institute on International Education (IIE) and (U.S. Department of State's Bureau on Educational and Cultural Affairs, 2020). Nevertheless, we note that because of very rigid curricula, many STEM undergraduate programs do not provide the flexibility needed for a semester-long global experience.

Other norms in the STEM disciplines also limit access to global experiences. Arguably, the prominence of the U.S. STEM education and research enterprise has been a strong rationale for concentrating the academic and professional training of our citizenry within itself. However, the increased globalization of the S&E workforce and enterprises has called into question this practice. Higher education leaders and others have sought to expand opportunities for undergraduates in STEM disciplines to engage in more global experiences that complement their technical research skills to include intercultural competencies needed for future leadership in the global S&E enterprise and economy.

## International Undergraduate Research Experiences

As higher education leaders and policymakers have grappled with strategies to increase STEM student access to and engagement in global experiences, one strategy that has gained traction is to combine global with undergraduate research. Several leaders have hypothesized that combining or layering high-impact practices may have potentially additive effects on student outcomes. Some studies have illustrated how layering high-impact practices result in positive outcomes for students (Finley and McNair, 2013). Accordingly, some faculty and academic leaders have posited that combining undergraduate research with global experiences delivered within an internship format could be an intriguing approach for preparing future leaders in STEM and supporting individuals for global STEM leadership (Duran et al., 2018).

Global undergraduate research experiences have the potential to be transformative for students with access to them. Within Higher Education and the STEM workforce, senior professionals actively engage in international research for collaboration and advancing innovation across borders within their respective STEM fields (Owens, 2018). However, few students are able to participate in international research during their undergraduate education. The significant financial commitment of such experiences and flexibility in the academic major are contributoring factors to access. To catalyze STEM student access and training in global experinces, the U.S. National Science Foundation (NSF) has taken a targeted approach by dedicating substantial funding to supporting the engagement of undergraduates in international research experiences. With this expansion of research offerings, undergraduate students are afforded a unique opportunity to engage in scholarly research pursuits and collaborations worldwide and broaden their perspectives of other countries and cultures. Moreover, international research experiences can significantly advance the professional, research, and technical skills of undergraduate researchers while exposing them to the world around them.

While extensive studies have investigated undergraduate research's impact on student development and retention, fewer studies have explored how these experiences in international research settings impact student learning and development (Green et al., 2008; McElmurry et al., 2003). Noting the limited exposure of STEM undergraduates to international experiences, URM in these disciplines are even more underrepresented than their peers in having global experiences. As we seek to understand how international

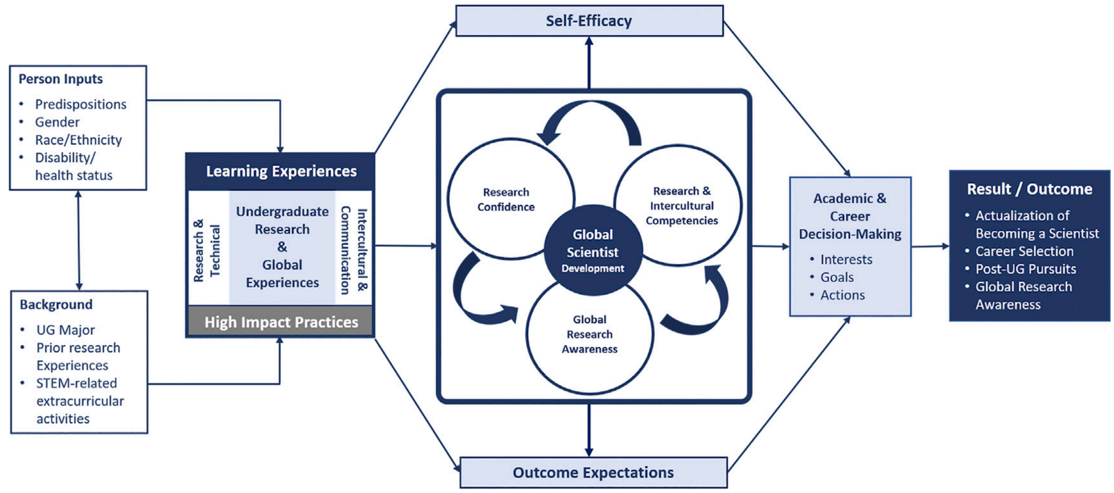


**FIGURE 3 |** A Conceptual Model Integrating Social Cognitive Career Theory, Science Identity, and Intercultural Competencies and Awareness to promote the development of undergraduates at Global Scientists.

research experiences impact those with access to these, it is imperative to include the impact of international undergraduate research on students from minoritized groups. Few studies have focused on URM engagement in global experiences, and fewer still have explored their engagement in international research experiences.

With this context in mind, this research study aims to explore the development of minority students' science abilities and confidence after participating in an international research experience. This study also explores how international research experiences developed participants' intercultural competence and awareness of global research and collaboration. This study has three guiding research questions:

1) How are international research experiences contributing to the educational experience of minority STEM undergraduates?
2) How do participants describe their growth in intercultural competence after living and working at an international research site?
3) How does minority students' participation in undergraduate international research programs support their actualization of being a scientist?

## CONCEPTUAL FRAMEWORK

Fundamentally, this empirical study considers how two intersecting high-impact practices, i.e., undergraduate research and global experiences, impact URM STEM students and their actualization of becoming STEM professionals. Noting academic and professional training are critical components of a student's intent to pursue a career in a STEM career field, this research study is grounded in Social Cognitive Career Theory (SCCT) and incorporates Science Identity (SI) and Intercultural Competence Model (ICM) theoretical frameworks. As such, our study presents a conceptual model integrating these frameworks to promote the development of undergraduates as Global Scientists (**Figure 3**). This model will investigate minority students' perceptions of the impact of international research experiences on the ideation of becoming a scientist, research confidence, and intercultural awareness. We hypothesize that these factors are essential to URMs actualizing goals of a STEM career.

Social Cognitive Career Theory forms the foundation of our conceptual framework. Developed by Lent et al. (1994), SCCT posits that individuals approach career development in three interrelated aspects: 1) self-efficacy, 2) outcomes, and 3) personal goals. Thus, individuals who believe or have confidence in their abilities to reach a favorable outcome are likely to pursue opportunities to achieve their goals. Consequently, SCCT illustrates the impact of affirmational growth opportunities. As students meet with challenges (or goals) that they achieve, they develop confidence (self-efficacy) in their ability to do well (*via* outcomes) in future challenges (goals). Even if each outcome is not ideal, if the students are learning and adapting through the process, they can develop confidence in their abilities to achieve their goals. Notably, the model considers the impact of one's identity on their educational and career development process.

By adapting the SCCT framework for understanding STEM career development, Byars-Winston et al. (2016) introduced the Modified model of SCCT incorporating Science Identity theory to offer a scientific approach to understand the development of academic and career goals for underrepresented minority groups in STEM. Previous research studies have indicated that the success in one's research experiences and future research careers is significantly predicated on their research related self-efficacy (Hurtado et al., 2009; Chemers et al., 2011; Byars-Winston, 2015).

Central to the modified SCCT model are the elements of Science Identity (Carlone and Johnson, 2007), which describes the three interrelated factors that comprise a student's science identity: competence (ascertaining and understanding scientific knowledge), performance (demonstration of scientific knowledge to an audience), and recognition (acknowledgment as a scientist by self and others). For underrepresented minorities in STEM, science identity is a significant factor in developing their academic and career goals (Carlone and Johnson, 2007; Byars-Winston et al., 2016). Simply put, minority students must have the knowledge (know-how) to be able to perform, perceive themselves as scientists, and have confidence that others perceive them as scientists to attain success within their desired STEM careers.

Our conceptual model is also informed by Deardorff's process model of Intercultural Competence (Deardorff, 2006; Deardorff, 2009). While the application of this framework is concentrated on short-term cultural immersion experiences, studies have reported notable success in the development of intercultural competence and global engagement among participants in an intentional cultural experience (Salisbury et al., 2013; Stebleton et al., 2013; Murphy et al., 2014). For context, the foundation of this model are five corresponding elements to cultivate growth in intercultural competence: attitudes (respect, openness, curiosity, and discovery), knowledge (cultural self-awareness and deep cultural knowledge), skills (listening, observing, interpreting, and relating), internal outcomes (adaptability, flexibility, and empathy), and external outcomes (effective and appropriate communication and behavior in an intercultural situation). As noted, intercultural competence development is an on-going process throughout one's life. Thus, each participant's understanding and development in this area varies at different points of the process. Consequently, our study focused on the internal and external outcomes of our participants in the laboratory and in society. Also, we explored how their orientation in an intercultural research setting heightened their awareness and understanding of science and research on a global scale.

To account for the layered effects of undergraduate research and international experiences, our conceptual framework posits an interplay of the three spheres, 1) Research Confidence, 2) Research and Intercultural Competencies, and 3) Global Research Awareness, as the foundation of minorities development in the total scheme of global scientist development. We theorize that the integration of these three spheres coupled with one's self-efficacy and outcome expectations is supported by their learning experiences. As such, these elements are essential components in developing an undergraduate's scientific interests, goals, and actions. Moreover, their participation in such experiences leads to actualization of becoming or being a scientist, career selection, post-undergraduate pursuits, and global research awareness.

## METHODS

To explore the research questions for this study, a qualitative research design was employed to allow for an in-depth, rich exploration of the unique experiences of the participants. Noting the small numbers of minority students engaging in international research experiences, a qualitative study can provide an empirical research approach to deepen our understanding of this critical population and their lived experience within and beyond their engagement in international research as an undergraduate. A single case study approach was employed to gain a comprehensive understanding of complex issues, topics, or problems within their real-world context (Merriam and Tisdell, 2015; Stake 1995; Yin, 2017). As prescribed by (Yin 2014; Yin 2017), case study research explores a real-life, bounded system (case) through multiple forms of data. For this study, the bounded case explored the experiences of undergraduate science researchers who participated in the France-Belgium International Research Experience for Undergraduates (iREU); most of the undergraduate research participants are minority students recruited through the Louis Stokes Alliance for Minority Participation in Science, Technology, Engineering, and Mathematics (LSAMP) Program (National Science Foundation, 2020). Because Louisiana State University is the home site for this international research program, IRB approval (IRBAM-20-058801) was granted from this institution to conduct research.

As mentioned, the focus of this research study was the iREU program hosted in France and Belgium. For each research experience, the student researcher identified a researcher at the international site with similar research interests and availability to mentor them during their program tenure. None of the participants had a relationship with their research mentor before the start of their program. Another notable characteristic of the research setting is the language differences in the professional and social environments. In the research lab, the standard language is English which did not pose any challenges as all of the students were native English speakers. However, the students did encounter language barriers in the social settings as the primary language is French.

### Participants

The general population of interest for the study was science majors who participated in the France-Belgium iREU program during their undergraduate academic careers. Given this iREU program's selective nature, we employed a convenience sampling method for participation in this study. Thus, participation in this study was open to all former iREU participants. Using the iREU program contact list, the former iREU participants were contacted *via* email to garner their interest and complete an initial demographic survey. By design with intentionality, a high number of these iREU participants were recruited from LSAMP programs in U.S. Colleges and Universities. From the initial survey, the participants were contacted *via* email to confirm their interest and schedule a virtual interview. All participants of this study participated in at least one summer in the international research program prior to Summer 2020 and were interviewed for this study in the latter months of 2020. The study's participants included eight 8) students. The participants included five 5) women and three 3) men. All of the participants were active LSAMP members at the time of their participation in the iREU. The majority of the participants identified as a member of a racial or ethnic minority; one participant identified as White. All of the participants engaged in STEM-related extracurricular activities, including

**TABLE 1** | Participants' profiles.

| Pseudonym | Gender | Race/Ethnicity | Undergraduate major | Undergraduate institution profile | Post-undergraduate pursuits |
|---|---|---|---|---|---|
| Emily | Woman | Mexican/Indigenous ancestry | Biology | Large, public, state university | Masters of science in biology |
| Jacob | Man | Black/Native american | Chemistry | Medium, public, state historically black college/ University (HBCU) | Chemistry Ph.D. program |
| James | Man | White | Marine science | Medium, public, state university | Inorganic chemistry Ph.D. program |
| John | Man | Latino | Chemistry and physics | Medium, public, state university | Post-baccalaureate research scholar |
| Mary | Woman | Native american | Chemistry | Small, public, regional university | Graduating senior |
| Natasha | Woman | Black/African american | Biochemical engineering | Large, public, land-grant university | Biochemical engineering Ph.D. program |
| Rosa | Woman | Latina | Cellular and molecular biochemistry | Large, public, state hispanic serving institution (HSI) | Biosciences Ph.D. program |
| Taylor | Woman | Latina | Materials chemistry | Medium, public, state university | Materials science & engineering Ph.D. program |

undergraduate research prior to the iREU. Six of the participants were enrolled in graduate programs at the time of the interview. The remaining two participants were in the process of applying for graduate programs; one participant was employed as a post-baccalaureate research associate, and the other participant was a graduating senior. Each of the participants provided their own pseudonyms, which ensured their identity remained confidential (**Table 1**); these pseudonyms will be used in the discussion of study findings.

## Data Collection and Analysis

As prescribed by the case study approach, we collected multiple forms of data, inclusive of documents and interviews (Stake, 1995; Yin, 2017). The primary mode of data collection was one-on-one semi-structured interviews that lasted approximately 30 min to 1 h. All of the interviews were conducted virtually using the Zoom platform and were recorded. The interview protocol included questions about the selection of their undergraduate degree path, current career and education path, iREU program experience, perspective on global research, and a reflection of their growth in research abilities and intercultural competence. The interview protocol utilized can be found in the **Supplementary Material**. The research team also analyzed the iREU program's grant, iREU year-end reports, promotional materials, and the LSAMP-NSF website to gain a better understanding of the organization's mission and context.

For the data analysis, each interview audio was transcribed verbatim using Rev transcription services. Once transcribed, each transcript was read thoroughly to gain an understanding of each participant in the study (Yin, 2017). Next, each transcript was uploaded in Dedoose qualitative coding software. Initially, each transcript was open-coded producing subcategories to develop a preliminary codebook. Each transcript underwent several rounds of axial coding, and connections were made between the subcategories to establish the major codes (Strauss and Corbin, 1998). Throughout the analysis, multiple data sources were actively examined to develop an in-depth understanding of each case individually in relation to the research questions (Yin 2014; Yin 2017). The final codebook consisted of 16 major categories. Once the codebook was finalized, the thematic analysis process began by categorizing codes by research questions. Next, emerging ideas were developed using the codebook and excerpts. The emerging ideas process interprets the data by using thoughts verbatim from participants or paraphrasing the comments from participants. Once completed, the emerging ideas were grouped by relationships to determine the final themes of the research study. Each step of the data analysis was documented individually to ensure trustworthiness. Throughout the data analysis process, there were several strategies of trustworthiness employed (Lincoln and Guba, 1985). The researchers employed member checking and peer-debriefing throughout the coding process to make sure the data was trustworthy. Once the study findings were completed, participants were asked to review the findings to ensure the trustworthiness of the results (Miles and Huberman, 1994).

## Positionality Statement

The research team included two faculty members and one doctoral candidate, whose research interests and professional responsibilities focus on Science and Undergraduate Research and has various experiences with the undergraduate science opportunities and the LSAMP program. The first author is a doctoral candidate and graduate researcher for the College of Science at a PWI. With a science educational background, her research agenda focuses on the experiences of historically underrepresented students in science programs. Her goal is to advocate for equitable academic opportunities for the retention and success of these student populations through her research. The corresponding author is a research faculty member in chemical education and an administrator within the College of Science at a PWI. As a leader on almost $30 million in extramural support from NSF, NIH, USDoEd, and philanthropic agencies, she has designed and implemented over 20 education projects, which have employed mentoring models to create and test development structures that cultivate self-efficacy and agency, particularly for groups historically underrepresented in STEM. Her research centers on studies of the persistence of individuals from all backgrounds in STEM higher education and careers, with a primary focus on faculty and student recruitment, retention, and success. The third author is a professor in the Department of Chemistry at a PWI for 22 years. In addition to his research program in polymer chemistry, he is currently the Principal Investigator for the NSF-funded International Research Experiences for Undergraduates that has sponsored over 80 students in a mentored research program in France and Belgium over the last nine years.

## RESULTS

The data analysis revealed four salient themes that emerged across the eight participants. We found that after participating in international research, minority undergraduate scientists: 1) Increased confidence in their science identity, knowledge, and abilities; 2) Gained and strengthen skills necessary to be a successful researcher, 3) Recognized the influence of international exposure on their growth personally and professionally, and 4) Expressed how monumental this research opportunity is for all minority students to experience.

### Theme 1: Increased Confidence in Their Science Identity, Knowledge, and Abilities

Throughout the interviews, participants shared how this international research experience helped them validate their sense of belonging and actualize their future in STEM. All participants were asked to rank their science confidence and competencies on a 10-point scale as a researcher before the iREU. The responses ranged from three to eight, with most of the participants citing their lack of confidence and competencies as the reason. Specifically prior to the iREU, Taylor shared:

> I will be 100% honest with you. I put off that I'm confident because in my specific major, there were eight of us, and I was the only woman, and the rest are White men. Then, the overall major has 32 of us, and I think three of us are women, and the other two were White. A lot of them were involved in research, and I looked down at myself very much as being part of the lower end of the spectrum. So, I ranked myself very low. Not only in my research, but I think just overall in my academic field. I believed that I can't be anything that special, but I tried to put off that confident front of I know it, but at least I'm embracing it.

Like Taylor, many of the participants struggled with their confidence and identity as a researcher. Upon reflection of the iREU experience, all participants were asked to rank their science confidence and abilities again on a 10-point scale as a researcher after the iREU. The responses ranged from six to ten, with most participants describing considerable growth in their confidence and competencies. After reflecting on her iREU experience in France, Rosa shared, "I would say now a 10. I feel more confident that no matter where I go, I'll be able to get the hang of it. Now, I know that even with the language barrier and the different culture, I can make it." The other participants shared similar sentiments of confidence and assurance in their science identity and competencies.

Additionally, most participants shared how this iREU experience affirmed and validated their sense of belonging and confirmed their pathway in STEM. Natasha passionately shared:

> I think France really just taught me it's okay to love what you love. I look at all these other people that love what they love and just seeing them speak at seminars. We had like weekly seminars, and I had to present at once. It was just like, wow, here I am. A black girl from the States, you know . . . I've had people tell me that you bring your full self, and frankly, I'm like, who else am I supposed to be? Like the white doctors? I'm not white. I'm black. I mean, I have personality, and I'm in STEM, you know. We exist. So I'm not about putting myself in a box. France taught me, be yourself.

Like Natasha, most of the participants returned home from the iREU affirmed in their sense of belonging and also with direction for their research interests and post-undergraduate pursuits. James shared, "I saw this as a pretty good long-term job prospect. This is research I find interesting, and this is research I want to do. It also prepares me for a potential future in industry because energy storage is not going away anytime soon."

Lastly, participants expressed how the positive feedback from their faculty mentors and research advisors bolstered their confidence and science identity after participating in the iREU. Whether through verbal affirmations or an increase in autonomy in the lab, all participants shared positive accounts of their faculty mentors and research advisors' response to their growth after participating in the iREU. Specifically, Jacob shared:

> It's reaffirming as well . . . I think they're even more blown away because I talked to my professor in France, and we recently published a JACS Publication. I told him, and he was like "I can't even imagine publishing for JACS, and you're already publishing there already," which is crazy. It's just being able to share those experiences with them. They definitely treat me as a colleague, basically, like someone who actually knows the research that they're talking about.

### Theme 2: Gained and Strengthened Skills Necessary to Be a Successful Researcher

Given the immersive nature of this research experience, all of the participants described substantial improvement in their research, technical and professional skills. Both Jacob, James, and John shared how their technical skills developed with conducting large-scale experiments. Specifically, John shared:

> One thing I learned was to work with large-scale reactions. I did reactions at my home institution in

> the milligram scales. It was very small. In France, I had to work with reactions that require 10 mg or 10 g of this . . . I gained a lot of confidence in working in the glove box for anaerobic reactions. It gave me a lot of confidence in working in that kind of environment.

Not only did participants gain new skills, but some also shared how they developed protocols and taught other researchers in their lab. Natasha recounted her experience teaching her lab mates how to perform a bacteria culture for the first time. She enthusiastically explained:

> And I was like, "Whoa. Girl, you're so capable. Look at you". I taught them how do the bacteria culture. They had not conducted one before in that lab. I helped them order the strains, learn how to do the culturing, and use the materials. I taught the whole protocol for conducting the experiment.

In addition to in-lab skills development, most participants shared how their professional skills, such as oral and written presentation of their research, improved. Specifically, Jacob shared

> I think that was one of the major things that opened my eyes on what does it mean to be a scientist. It's not just having the confidence to step into the lab. It's really having that follow through and being able to write about something to unknown audience. You are writing about your research, and you don't know who's going to be the reviewer. You don't know if someone's going to be an expert in the field, or if they're going to be tangentially related to it. I definitely learned that science has a lot more to do with writing than I had originally thought . . . That's when I understood the skill sets of a scientist. It's not just lab and understanding the science. It's really having this academic voice. Can you convince people that you know what you know? . . . I had to also present poster presentations, but it was really giving talks and group meetings, where I learned more appropriate ways to present your work. It's something I never really had too much of that experience before.

Like Jacob, several of the participants shared how their communication skills as a researcher strengthened to be able to discuss their research with a wide variety of audiences. James shared, "I think it was the general science communication, I got a lot more comfortable with it. I got a lot more comfortable with just talking about the work I was doing, but in a more casual format".

Among their skills development, all of the participants spoke to the development of their work-life balance adopted from their experience with this specific iREU. Specifically, Rosa shared:

> I am accustomed to Latino-Hispanic culture, and White people as well . . . For me, here in the U.S. it's like no holidays, you have to work mentality. Over in France, it's like, we don't have to come on weekends, or you don't have to stay after five or six. I was not accustomed used to that. I was accustomed to working all day, every week. In France, they taught me that balance. It also showed me that if you focus really on what you need to do, you can be really proficient. You don't need to stay all day long in the lab to get the data that you need to get really good results.

As participants reflected on the work ethic and culture in France and Belgium, Emily summed it up perfectly: "I work to live. I don't work to work or live to work". In contrast to their fast-paced research experiences in the United States, all of the participants shared how their experience in the France-Belgium iREU encouraged them to foster a healthy work-life balance for their STEM careers. For Natasha, she shared, "I think what's helped me for grad school now is learning that work-life balance. In college, I feel like with STEM majors, we get caught up in getting work done, grades, everything. But in France, And I tell you, well, the whole E.U. cares about your health and your family.

## Theme 3: Recognized the Influence of International Exposure on Their Growth Personally and Professionally

For many of the participants, this international research experience broadened their understanding and awareness of research collaborator relationships across countries. Participants remarked how imperative it is to have international research collaboration in the advancement of STEM to solve world issues. Specifically, Mary shared:

> It gives you a broader worldview. It's easy to get stuck in your research lab. You do know that other people are doing the same thing that you're doing, not literally but metaphorically in a lab, all over the country, all over the world. However, to physically go to a different lab in a different country, it really drives the point home. Given this recent pandemic, that's one thing that keeps harking back to my mind. People all over the globe are working on these vaccines. People from all different walks of life, all different educational levels are coming together to work on something. I think that's the beautiful thing about Chemistry.

Similar to Mary, Emily shared how international collaborative research expanded her perspective of science and enlightened her to the necessity for diverse backgrounds and perspectives in science. She explained:

> Science involves a lot of people, and everyone needs everyone. Everyone has a part to play, and your background plays a part. I feel like bringing a lot of people from a lot of different countries, you have different perspectives. You have different backgrounds and ways of thinking of new questions. I definitely feel like collaboration and working in

> different labs in different countries definitely expands how we do science in general.

Not only did their perspective on global research and international collaboration evolve, but several of the participants shared how they have been able to establish their own research collaboration teams. Specifically, Taylor shared, "I'm in the process of working to publish a paper with some of my collaborators from France . . . I think that really put it into perspective for me when I went abroad that as a scientist I can not only just contribute to the immediate field, but to the larger field, and different ways that could I do that". Similarly, Natasha's research mentor encouraged her to develop international collaborations during her time in France. She shared

> He was like, "We are not publishing enough internationally, with co-authors from different countries. Yeah, we're good at collaborating in the U.S. but we could improve international collaborations." And I think that's something I took from the experience. We have all these resources. I don't believe in reinventing the wheel because someone's done something or part of what you want to do somewhere. Figure it out, email them, get a conversation going".

In addition to their growth professionally, participants discussed how engaging with individuals from different countries and cultures expanded their personal views on various topics. James recounted his experience discussing politics with colleagues during the U.S. 2016 election. Specifically, he shared:

> While I was there, we had the 2016 primary election and then the 2016 general election. I got exposed to that from a very outside perspective. It was really interesting seeing how different the culture there was around just discussing politics. It was a very comfortable topic to chat about. The thing that I found really refreshing was that the culture around that was that it was okay to talk about things and have different opinions, in a way that it's not in the U.S.

Similar to James, Jacob reflected on his conversations discussing the similarities and differences in race relations in U.S. and France. Specifically, he shared, "In America, of course, a lot of people understand what it means to have these minority programs or what affirmative action looks like, or a lot of these terminologies are thrown around that a lot of Americans understand. But people in France, they had no idea what I was talking about".

### Theme 4: Expressed How Monumental This Experience is for all Minority Students to Partake in

After reflecting on this international research experience, all of the participants resoundingly expressed how this opportunity affirmed the trajectory of their lives as scientists. As Taylor reflected on the iREU experience, she expressed the gravity of this opportunity in hindsight. She shared, "I didn't realize it either at the time, the gravity of the opportunity that we were being given. I don't think I realized it until I went home . . . this is not an everyday thing, and this is something so out of left field that so many students don't get the opportunity to do it. I think I would have maybe appreciated it more in the beginning to understand that". Similar to Taylor, several participants shared how grateful they were for the opportunity. James summed up their sentiments perfectly, "It definitely changed my path forward. It really helped me to define what I want to do and where I'm at now. I absolutely would not be here right now if I hadn't done that program. I'm really, really grateful for that".

In addition to their gratitude for this international research opportunity, participants expressed how the LSAMP program has been integral in their science success. Taylor shared, "It's not that you need the help, it's that these people want to help you because they see something in you that you're capable of doing it." Similar to Taylor, Rosa shared how LSAMP provides an all-encompassing support system for those who participate. Specifically, she said, "I think it's a complete package because here, the people from LSAMP really supports you, not only at the professional level, but also, at the personal level . . . no matter the situation, you know they have your back, because there's a constant personal communication all the time".

Given the significance of this iREU on their overall development as scientists, all of the participants exclaimed how monumental this opportunity would be for all minority students to experience. Natasha passionately shared, "I'm very grateful for this experience. I will brag about France to the mountaintops. People would probably get annoyed by it, but I want to tell it so that little girls can know that they can go to France, too, and do research". Similar to Natasha, Jacob enthusiastically expressed "that this experience is the linchpin that says, "You're not bound here. You can succeed outside, you can succeed in any environment, basically. I think it's really just that experience I took from there. I left France a more confident person in terms of just all aspects of life. I think that's really what that IREU trip means to me".

## DISCUSSION

Previous studies on undergraduate research generally focused only on U.S.-based research experiences for all science students. Conversely, little is known about the benefits of international research experiences on the science development of minority students. Thus, our study focused on exploring the development of science identity and competencies in minority undergraduate scientists after participating in an international research experience. The three research questions in this study sought to illuminate the perceived benefits of iREUs through our eight participants' experiences. Although each participant had a highly individualized research experience, there were similar mutual benefits gained from their participation in the iREU.

Firstly, our findings answered the first research question by presenting detailed insights on the value of international research to minority STEM undergraduates' educational experience. Aligned with prior literature on undergraduate research, we too found that our participants experienced substantial development in their research confidence and competencies. While each participant's individual research experience was unique, most of them attributed the increase in autonomy, responsibility, and exposure to new techniques for their growth in confidence and competencies. Aligned with our conceptual framework, our findings corroborate the substantial contribution of iREUs to our participant's research self-efficacy and science identity development. Thus, our participants spoke extensively about their affirmed sense of belonging and direction for their post-undergraduate endeavors and STEM careers. At the time of their interview, six of the participants were enrolled in graduate programs and actively conducting research. The remaining two participants were in the application process to their desired STEM graduate program. Therefore, we concur that international research experiences can contribute substantially to the research self-efficacy, confidence, and competencies development of undergraduate students.

Secondly, unlike previous studies on undergraduate research, our research study explored the benefits of research at an international site for U.S. students for a minimum of three 3) months. Most of the previous literature on international exposure focuses on short-immersion experiences, like study abroad, for students. Thus, an experience of this length and magnitude presents increased opportunities for developing intercultural competence and awareness in participants. Our findings answered the second research question by highlighting the numerous opportunities for participants to exchange ideas and perspectives with individuals from diverse backgrounds personally and professionally. Aligned with the development process of Intercultural Competence, this finding affirms that this long-term immersion research experience is a unique opportunity to engage students in the on-going intercultural competence development process in various facets of life. The students we interviewed shared that a significant benefit of the international research experience was the opportunity to learn from individuals from diverse backgrounds and to develop relationships with research collaborators across the world.

In addition to the development of science identity, self-efficacy, and competencies, our findings answered the third research question through the summation of our participants' stories, specifically how they perceived this experience as crucial in their actualization of becoming a scientist. Although all of the participants engaged in previous research experiences in the U.S. many of them stated that the ability to conduct research independently and collaboratively with researchers from across the world was unique to their iREU experience and validated their science identity. Several of the participants recounted specific instances in which they came to see themselves as a scientist. For most participants, one such example was the positive interactions and feedback from research advisors and mentors in the U.S. and France. Our findings illustrated how the iREU developed our participants' competence, performance, and recognition through the lens of Science Identity, showing that the competencies, confidence, and self-efficacy developed in an international research experience reinforced their identity as a scientist. Moreover, their actualization as a scientist is seen through their commitment to encouraging and supporting others to pursue their desired STEM careers. Our findings suggest the importance of peers sharing their experiences to promote retention and persistence in STEM fields.

With a general understanding of research in the United States, participants were exposed to science and research conducted through the lens of another culture. As a result, they recognized the value and importance of international research collaboration with researchers worldwide for the advancement of their respective STEM fields. For many of the participants, this international research experience was their first time viewing themselves as contributing members of their STEM field on a global scale. Certainly, their prior research experiences were impactful on their development as scientists, but several of the participants indicated that the independence gained in the lab through their IRE gave them a different level of confidence in their abilities. In sum, our findings illuminate the interplay of each sphere of development supported the participants' foundation of their global scientist development.

## Implications for Policy and Practice

Participants noted the importance of participating in an iREU to their overall development as scientists, specifically highlighting how the financial support was critical to their international experience coming to fruition. One student mentioned the financial commitment might be a deterrent for some students with dire financial situations. It is vital to consider how to provide iREU opportunities to STEM students with challenging financial situations.

This study also has important implications for STEM faculty and institutions. Based on our participants' accounts, their iREU experience proves to be a worthy investment for advancing their careers and contributions to their respective STEM fields. With the National Science Foundation's continued support, more STEM faculty should consider developing more iREU program opportunities across various STEM disciplines. It is valuable for colleges and universities to integrate international research opportunities within academic curriculums as unique learning experiences that can cultivate students' science identity and goals while boosting their appeal for the job market after graduation.

While our study focused on the international research experience, it is relevant to note that all participants were actively involved in the LSAMP program. Several of the students shared how their participation in LSAMP exposed them to many beneficial opportunities like iREUs. However, one student shared that the benefits and magnitude of international research experiences could be better explained from the program. As the LSAMP program continues to expose students to iREUs, it is exceedingly critical to detail the benefits of participating in international research experiences for students to grasp the magnitude of this opportunity.

## Future Research and Conclusion

While we could not explore their nuanced experience in this paper, two women in the study shared instances where they felt challenged based on their gender. Also, several participants mentioned the lack of representation of women advisors in their experiences. Therefore, future research will explore the experiences of women in STEM participating in international research. For example, a similar research study could examine the experiences of women in STEM fields traditionally dominated by men. The opportunity to explore their experiences could provide insights into how they combat gendered stereotypes regarding women in STEM in an international setting.

The current study brings to light the substantial benefits of international research experiences on the science identity, confidence, and competencies of minority students pursuing STEM careers. Although the findings are not representative of all iREU programs, our study adds significant insights to this literature area. For our participants, we find that this experience was a life-changing opportunity that has broadened their understanding of research on a global scale and affirmed their stance on their capability within their STEM fields. Future research in this area could track the progress of the iREU participants over a period of time. A longitudinal study of participants could illuminate the long-term benefits of an iREU to its participants' career trajectory.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the LSU Institutional Review Board (IRBAM-20-058801). The participants provided their verbal informed consent to participate in this study.

## AUTHOR CONTRIBUTION

ZW-K and RD, equally conceptualized the research study with insights from DS. RD conducted the research study and serves as first author of the article. She, along with ZW-K, contributed to the organization of the manuscript. All authors contributed to writing sections of the manuscript and editing of the article. All authors have read and approved the submitted version.

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## SUPPLEMENTARY MATERIAL

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REVIEW
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# How to Promote Diversity and Inclusion in Educational Settings: Behavior Change, Climate Surveys, and Effective Pro-Diversity Initiatives

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We review recent developments in the literature on diversity and inclusion in higher education settings. Diversity interventions increasingly focus on changing behaviors rather than mental constructs such as bias or attitudes. Additionally, there is now a greater emphasis on the evaluation of initiatives aimed at creating an inclusive climate. When trying to design an intervention to change behavior, it is advised to focus on a segment of the population (the "target audience"), to try to get people to adopt a small number of specific new behaviors (the "target behaviors"), and to address in the intervention the factors that affect the likelihood that members of the target audience will engage in the new target behaviors (the "barriers and benefits"). We report our recent work developing a climate survey that allows researchers and practitioners to identify these elements in a particular department or college. We then describe recent inclusion initiatives that have been shown to be effective in rigorous empirical studies. Taken together this paper shows that by implementing techniques based on research in the behavioral sciences it is possible to increase the sense of belonging, the success, and the graduation rate of minority students in STEM.

**Keywords: higher educaction, STEM–science technology engineering mathematics, diversity, inclusion, behavior change, intervention**

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## INTRODUCTION

Women, people of color, members of the LGBTQ + community, and members of other marginalized groups continue to be underrepresented in STEM fields (National Science Foundation, 2020). Students from these groups are the target of both subtle and overt acts of discrimination, face negative stereotypes about their abilities, and experience disrespect and lack of inclusion by their instructors and peers (Spencer and Castano, 2007; Wiggan, 2007; Cheryan et al., 2009). For example, students from marginalized groups are often assumed to be less intelligent and competent (Moss-Racusin et al., 2014) and are often excluded when students form study groups or gather outside of class (Slavin, 1990). Students from marginalized groups receive less challenging materials, worse feedback, and less time to respond to questions in class than their peers (Beaman et al., 2006; Sadker et al., 2009). Additionally, the cultural mismatch between university norms and the cultural norms that students from marginalized groups were socialized in frequently leads to increased stress and negative emotions for these students (Stephens et al., 2012).

Not surprisingly, students from marginalized groups are far more likely than high-status group members (e.g., White people, men) to report feeling as though they do not belong at universities

(Walton and Cohen, 2011). This is particularly problematic given that social belonging has been shown to be a key predictor of educational outcomes (Dortch and Patel, 2017; Wolf et al., 2017; Murphy et al., 2020). Students who feel a greater sense of belonging are more likely to persist to graduation (Strayhorn, 2012). Additionally, increased concerns about belonging can lead students to view common challenges—such as struggling to make friends or failing a test—as signs that they do not belong, promoting psychological disengagement and poorer educational outcomes (Walton and Cohen, 2007). These challenges are exacerbated in STEM fields, which are typically dominated by members of high-status groups (Rainey et al., 2018). Students from marginalized groups are particularly vulnerable to dropping out of STEM programs and the lack of a sense of community greatly contributes to this vulnerability (O'Keefe, 2013).

It is clear then that the key to promoting academic success and retention of students from marginalized groups in STEM is creating an inclusive climate. In this article we will review recent developments within the diversity and inclusion literature about how to best promote inclusive behaviors and create an inclusive climate at colleges and universities. We will start out by describing recent shifts in the literature emphasizing the importance of changing behaviors rather than attitudes and the necessity to systematically evaluate diversity interventions. We will then review the key elements to designing effective interventions to promote diversity and inclusion. We will also talk about the use of focus groups and climate surveys to acquire the relevant background knowledge needed to design effective interventions. In the final section, we present recent initiatives that have successfully promoted diversity and inclusion in a variety of ways.

## Recent Developments in Research on Diversity and Inclusion

### A Shift From Reducing Bias to Promoting Inclusive Behavior

Even though prejudice is communicated through behavior (Carr et al., 2012), the traditional approach to prejudice reduction was to change explicit and implicit bias. The focus on bias was based on the assumption that changes in attitudes will subsequently lead to changes in behavior (Dovidio et al., 2002). The universal acceptance of this assumption is surprising given the weak evidence for a link between attitudes and behavior. Explicit biases and attitudes more generally have been shown to predict behavior only weakly (Wicker, 1969; Ajzen and Sheikh, 2013). Similarly, there is little to no connection between implicit bias and behavior (Kurdi et al., 2019; Clayton et al., 2020). Implicit bias scores explain, at most, a very small proportion of the variability in intergroup behavior measured in lab settings, and this proportion is likely to be even smaller in more complex, real-world situations (Oswald et al., 2013). Further, a change in implicit bias is not associated with a change in intergroup behavior. Lai et al. (2013) and Forscher et al. (2019) showed that while a variety of methods have been developed to change implicit bias, these methods produce trivial or nonexistent changes in intergroup behavior, and if they do, none of them last longer than 24 hours.

A growing body of research suggests that it is possible–and likely more effective–to focus on promoting inclusive behavior rather than improving individuals' attitudes toward outgroup members. For example, Mousa (2020) randomly assigned Iraqi Christians displaced by the Islamic State of Iraq and Syria (ISIS) either to an all-Christian soccer team or to a team mixed with Muslims. Christians with Muslim teammates were more likely to vote for a Muslim from another team to receive a sportsmanship award, register for a mixed faith team next season, and train with other Muslim soccer players six months after the intervention. However, attitudes toward Muslims more broadly did not change. Similarly, Scacco and Warren (2018) examined if sustained intergroup contact in an educational setting between Christian and Muslim men in Kaduna, Nigeria led to increased harmony and reduced discrimination between the two groups. After the intervention, there were no reported changes in prejudicial attitudes for either groups, but Christians and Muslims who had high levels of intergroup contact engaged in fewer discriminatory behaviors than peers who had low levels of intergroup contact. These findings demonstrate that while promoting both positive intergroup attitudes and inclusive behavior is ideal, it is necessary to target inclusive behaviors directly rather than trying to change people's biased attitudes with the assumption that such change will translate into a subsequent behavior change.

### Greater Emphasis on Evaluation

Since the Civil Rights Act of 1964, researchers and practitioners have developed a variety of initiatives to combat racial prejudice in the United States (for reviews see Murrar et al., 2017; Paluck and Green, 2009; Paluck et al., 2021). Although these initiatives have been tested in individual studies, primarily in the lab, many of them have not undergone the rigorous scientific testing that is required to be able to conclude that they are effective in real-world settings (Paluck and Green, 2009). Further, the evaluation studies frequently examined only the effects on self-report attitudes and not behavioral outcomes, which is problematic for reasons outlined in the previous paragraphs. In light of this deficit, there has been a recent shift in this field of research which now emphasizes the need for systemic evaluation of the effectiveness of diversity initiatives in the field (Moss-Racusin et al., 2014).

Recent work examining the effectiveness of diversity initiatives has found mixed evidence for the idea that existing strategies reduce discrimination, create more inclusive environments, or increase the representation of marginalized groups (Noon, 2018; FitzGerald et al., 2019; Dover et al., 2020). Most diversity training or implicit bias training workshops have been shown to be ineffective (Bezrukova et al., 2016; Chang et al., 2019). Some interventions meant to promote diversity and inclusion actually achieve the opposite effect (Dobbin and Kalev, 2018). For example, Dobbin et al., (2007) found that diversity training workshops had little to no effect on improving workplace diversity and some actually led to a decline in the number of Black women in management positions at companies. Similarly, Kulik et al. (2007) found that employees often respond to mandatory diversity training with anger and resistance and some report increased animosity toward members of marginalized groups afterward.

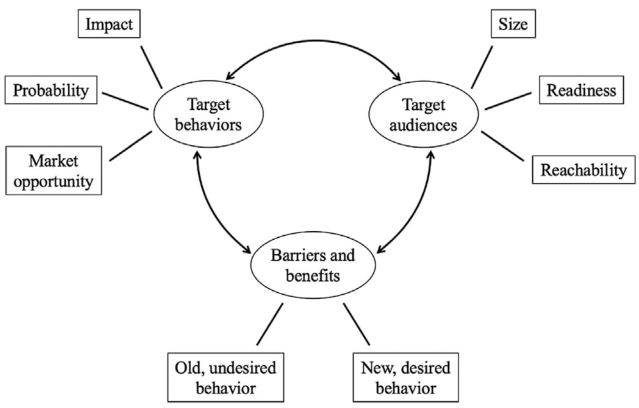


**FIGURE 1 |** Key elements to consider designing a behavior change intervention (adapted from Campbell and Brauer, 2020).

## DESIGNING SUCCESSFUL BEHAVIORAL INTERVENTIONS

Behavior change interventions tend to be more effective if they involve a systematic, focused approach which consists of identifying and targeting specific behaviors, catering the intervention to a particular audience, and incorporating in the intervention relevant information about factors that affect how members of the target audience appraise the target behavior (Campbell and Brauer, 2020). Below, we have outlined several methodological and theoretical considerations for practitioners whose goal is to develop a behavioral intervention to promote diversity and inclusion (see **Figure 1**).

### Selecting a Target Behavior

Once a broad issue has been identified (e.g., promoting diversity and inclusion at a university department), it must be distilled into a measurable, actionable goal (Smith, 2006). For example, one might focus on an outcome such as reducing the racial achievement gap. It is critical that the desired outcome is quantifiable, as that will allow one to determine whether a behavioral intervention has been a success.

The next step is to identify and select a desired behavior to be adopted (i.e., the target behavior). The goal is to choose a target behavior that will lead to the desired outcome if people actually perform it (Lee and Kotler, 2019). Continuing with the previous example, a behavioral intervention with the goal of reducing the racial achievement gap may target behaviors such as encouraging White students to include students of color in their study groups and social events or motivate instructors to highlight to a greater extent the contributions of female scientists. Sometimes it is possible to promote multiple similar target behaviors in the same intervention.

To identify potential target behaviors it is usually advised to conduct background research (see next section of this paper). This research may involve semi-structured interviews or focus groups with members of marginalized groups. Climate surveys with closed and open-ended questions can be equally informative. The goal of the background research is to determine the behaviors that affect members of marginalized groups the most. It is crucial to know what behaviors they find offensive and disrespectful and thereby decrease their sense of belonging, and what behaviors make them feel included, welcomed, and cared for. Examples of target behaviors to promote inclusion are attending diversity-outreach events or consciously forming diverse work groups.

Once a list of potential target behaviors has been established, it is advised to choose one of them for the intervention. The choice can be guided by evaluating each potential target behavior along a number of relevant dimensions (McKenzie-Mohr, 2011). One may consider, for example, the extent to which the effect of changing from the old behavior to the new target behavior will have a large effect ("impact"), how likely people are to adopt the target behavior ("probability"), and how many people currently do not yet engage in the target behavior ("market opportunity"). For instance, an intervention seeking to reduce discriminatory behaviors toward members of the LGBTQ + community in STEM contexts might consider focusing on encouraging students to learn what terms hurt the feelings of queer people and then abstain from using them, get the students to avoid gendered language, or promote joining a queer-straight alliance at their university. While a large number students joining a queer-straight alliance would have a big effect on the sense of belonging of members of the LGBTQ + community (high impact), it is unlikely many students will adopt this behavior if they are not already predisposed to do so (low probability). Similarly, it may be easy to get students to switch to gender neutral language (high probability), but if most students are already using this language then promoting this behavior will lead to only minor improvements (low market opportunity).

Ultimately the goal is to choose a single behavior (or a small set of interrelated behaviors) that will make the biggest difference for members of marginalized groups and then design an intervention that specifically encourages the adoption of this behavior (Wymer, 2011).

### Selecting a Target Audience

One of the most vital considerations when designing a behavioral intervention is the selection of a specific target audience (Kotler et al., 2001). Different segments of the population are receptive to different messages, possess different motivations, and have different reasons for engaging or not engaging in the desirable behavior (Walsh et al., 2010). Although all individuals in a specific setting are usually exposed to a given pro-diversity initiative (e.g., everyone in a specific department or college), the initiative is more likely to be effective if it is designed with a specific subset of the population in mind (French et al., 2010).

The first step in determining a target audience is to segment the population into various groups along either demographic criteria (e.g., Whites, men), occupation (e.g., students, teaching assistants, faculty, staff), or psychological dimensions (e.g., highly egalitarian individuals, individuals with racist attitudes, folks in the middle). The background research described in the next section will help practitioners identify the groups that have the most negative impact on the climate in a department or college. One can find out from members of marginalized groups, for example, which groups treat them in the most offensive way or which kind of people have the most negative impact on their sense of belonging.

Although multiple groups may emerge as potential target audiences, it is generally advised to choose only one as the focus of the intervention. Similar to the process of selecting a target behavior, the choice of the target audience can be guided by considering a number of relevant dimensions: How large is the segment, and what percentage of the members of this segment currently do not yet engage in the target behavior ("size")? To what extent are members of this segment able, willing, and ready to change their behavior ("readiness")? How easy it is to identify the members of this segment and are there known distribution channels for persuasive messages ("reachability")? Teaching assistants may be a group that can easily be instructed to adopt certain behaviors (high reachability), individuals with hostile feelings toward certain social groups may not be willing to behave inclusively (low readiness), and academic advisors may be a group that is too small and that students from marginalized backgrounds interact with too infrequently to be chosen as the target audience (small size).

Most effective behavior change interventions are designed with a single target audience in mind. That is, the communications and campaign materials are designed so that they are appealing and persuasive for the members of the chosen target audience. The objective should thus be to choose a single target audience that can be persuaded to adopt the target behavior and has a big impact on how included members of marginalized groups feel in the department or college.

### Barriers and Benefits

It is critical to consider the factors that influence the likelihood that members of the target audience will engage in the desired target behavior, the so-called "barriers" and "benefits" (Lefebvre, 2011). Barriers refer to anything that prevents an individual from engaging in a given behavior. Benefits are the positive outcomes an individual anticipates receiving as a result of engaging in the behavior. The ultimate goal is to design an intervention that makes salient the target audience's perceived benefits of the new, desired target behavior and the perceived barriers toward engaging in the current, undesired behavior (McKenzie-Mohr and Schultz, 2014).

Practitioners likely want to conduct background research to learn about the target audience's motivations to engage in various behaviors. This can again be done with interviews, focus groups, or climate surveys, but this time the responses of members of the target audience, rather than the responses of members of marginalized groups, are most relevant. One should find out why members of the target audience currently do not perform the target behavior. Are there any logistic barriers (e.g., lack of opportunity) or psychological barriers (i.e., discomfort experienced around certain groups)? Are there any incorrect beliefs that underly the current behavior? The background research should also identify the positive consequences members of the target audience value and expect to experience when performing the target behavior. These consequences can then be highlighted in the intervention.

Both barriers and benefits can be abstract or concrete, internal or external, and real or perceived. For example, if an intervention seeks to encourage students from different backgrounds to be friendly to one another in the classroom members of the target audience may be apprehensive when interacting with outgroup members due to fear of saying something offensive (a barrier) but would interact more frequently with outgroup members if they believed that it would provide them an opportunity to make new friends (benefits). A well-designed behavioral intervention would then use this information to craft persuasive messages that directly address the target audience's barriers and benefits. In this specific example, the intervention might involve providing people with tools to avoid offensive language and emphasize the potential to make new friends.

### Elements That Increase the Persistence of a Behavioral Change

Sometimes people adopt a new behavior but then switch back to the old, undesired behavior after a few days or weeks. What can be done to increase the persistence of behavior change? One strategy that has proven to be particularly effective is to change the assumptions that people make about themselves and their environments (Frey and Rogers, 2014; Walton and Wilson, 2018). For example, believing that one is not culturally competent will lead to interpreting difficult interactions with outgroup members as proof of this assumption. The more entrenched these beliefs become, the more difficult behaviors are to change. However, the human tendency to "make meaning" of oneself and one's social situations can be harnessed for positive behavioral change. By altering the assumptions that lead to undesirable behaviors, it is possible to set in motion recursive cycles where a person's new behavior leads to positive reactions in the environment, which in turn reinforces the self-representation that they are "the kind of person" who cares about this issue (e.g., diversity) and engages in these behaviors (e.g., inclusive behaviors). Consider an example from a different domain: Fostering a growth mindset where students start to believe they can improve through practice will change how they interpret successes and failures, thereby disrupting the negative feedback cycle that leads to poorer performance in school (see Yeager et al., 2019).

In addition, interventions that foster habit formation are more likely to increase the persistence of new behaviors (Wood and Rünger, 2016). Interventions can promote habit formation by increasing the perceived difficulty of performing an undesirable behavior or by decreasing the perceived difficulty of doing the new target behavior. People will most often engage in behaviors that they *perceive* as being easy to do, regardless of whether or not the difference in difficulty is minimal. Additionally, providing easy to understand, recurring cues that encourage desirable behaviors and disrupt old, undesirable behaviors can help facilitate habit formation.

## HOW TO CONDUCT RELEVANT BACKGROUND RESEARCH

There are a variety of ways how members of higher education institutions can identify the diversity-related issues that should be addressed in their department or college. The most frequently used methods are focus groups and climate surveys. We will discuss each of these methods below.

Focus groups are effective because a group member's comment may cause other members to remember issues that they would not have thought of otherwise. It is easy to recruit students from marginalized groups by appealing to their departmental citizenship or by promising attractive prizes (e.g., two $100 gift certificates that will be given out to two randomly selected members of the focus group). It is generally advised to form groups of individuals sharing some social identity (i.e., African Americans, Latinxs, women in technical fields). Most individuals feel more comfortable voicing their concerns if the focus group facilitator also shares their social identity. Many universities have skilled focus group facilitators, but if necessary, it is possible to train research assistants by directing them to appropriate resources (Krueger, 1994; https://fyi.extension.wisc.edu/programdevelopment/files/2016/04/Tipsheet5.pdf).

Focus group members should be encouraged to talk about the situations in which they felt excluded, disrespected, or discriminated against. For example, focus group members might be asked questions such as "What exactly did the other person do or say? Where did the situation occur (in the classroom, during office hours)? Who was the other person (peer, instructor, staff)?" Focus group members should then be asked about the situations in which they felt included, respected, and cared for. Again, the goal should be to obtain precise information about the exact nature of the behaviors, the place in which they occurred, and person who engaged in the behaviors. It is useful to ask about the relative impact of these negative and positive behaviors. For example, one might ask "If you could eliminate one behavior here in this department which one would it be?" and "Among all the inclusive and respectful behaviors you just mentioned which one would increase your sense of belonging the most?".

To assess the barriers and benefits of the potential target behaviors it can be useful to conduct focus groups with individuals who a priori do not come from any of the marginalized groups mentioned above. The facilitator can describe the negative behaviors (without labeling them as discriminatory) and ask whether the focus group members sometimes engage in them and if they do, why. One might ask about potential pathways to eliminate these undesired behaviors, e.g., "What would have to be different for you–or your peers–to no longer behave like that?". The next step is to have a similar discussion about the positive target behavior: What prevents focus group members currently from engaging in this behavior? What could someone say or show to them so that they would engage in this behavior? If some members of the focus groups have recently started to do the positive behavior, what got them to change in the first place?

Focus groups are also useful to determine how able, willing, and ready to change their behavior members of different potential target audiences are. Several factors contribute to individuals' "readiness" to change their behavior. These factors include openness to acting more inclusively (Brauer et al., in press), internal motivation to respond without prejudice (Plant and Devine, 1998), lack of discomfort interacting with members of different social groups (Stephan, 2014), and general enthusiasm for diversity (Pittinsky et al., 2011). Facilitators can get at these factors by asking the members of the focus group about their motivation and perceived ability to engage in the target behavior.

Climate surveys are effective because they usually provide data from a larger and thus more representative sample in a given department or college. Various techniques exist to increase the response rate of respondents (e.g., Dykema et al., 2013). The exact content and length of a climate survey depend on the participant population and the frequency with which the survey is administered. The online supplemental material contains two examples developed by the Wisconsin Louis Stokes Alliance for Minority Participation (WiscAMP), one for graduate students of a university department and one for all undergraduate students on a campus. Other climate surveys used in higher education and numerous relevant references can be downloaded from this web address: http://psych.wisc.edu/Brauer/BrauerLab/index.php/campaign-materials/information-resources/

All climate surveys should measure demographic information, but in smaller units, anonymity may be an issue. Once gender identity is crossed with racial/ethnic identity and occupation (e.g., postdoc vs. assistant professor vs. full professor) it may no longer be possible to protect all respondents' anonymity. The solution is to form a small number of relatively large categories such that it is unlikely that there will be fewer than five respondents when all these categories are crossed with each other. If the analyses reveal that certain groups of respondents are too small, then the presentation of the results should be adjusted. For example, the means can be broken down once by gender identity and once by race/ethnicity, but not by gender identity *and* race/ethnicity.

To address the anonymity issue, we recently conducted a climate survey in which we only asked two demographic questions: "Do you identify as a man, yes or no?" and "Do you identify as a member of a marginalized group (unrelated to gender identity), yes or no?" We justified the use of these questions in the survey by explaining that the gender identity question was asked in this way because research shows that individuals who identify as men are less often the target of sexual assault than those who do not identify as men. We also provided a brief definition of "marginalized groups."

Climate surveys have two goals. They should provide an accurate reading of respondents' perception of the social climate and they should suggest concrete action steps about initiatives to be implemented (see **Table 1** for a list of constructs that are frequently measured in climate surveys). To achieve the first goal the climate survey should contain at least one question about the overall climate and several questions about specific feelings related to the social climate. In addition, the survey should assess sense of belonging, as well as mental and physical health. Most climate surveys also include items about respondents' experiences of discrimination and their intention to remain in the institution (sometimes referred to as "persistence"). Finally, the climate survey may assess a variety of other constructs such as respondents' perception of the institution's commitment to diversity, their personal values related to diversity, their level of discomfort being around people from other social groups (sometimes referred to as "intergroup anxiety") and self-reported inclusive behaviors.

**TABLE 1 |** List of constructs that are frequently measured in climate surveys.

| Construct | Sample item |
|---|---|
| General perception of climate | How satisfied or dissatisfied are you with the overall climate that you have experienced in the department within the past 12 months? |
| Specific feelings related to climate | Thinking about this semester in the department, overall, how often did you feel–respected [. . . welcome, included, cared for, etc.] |
| Perception of climate for particular groups | Based on what you have experienced or witnessed, to what extent does the department provide a comfortable, welcoming climate for–members of marginalized racial and ethnic groups [. . . women, individuals from financially disadvantaged backgrounds, etc.] |
| Sense of belonging | To what extent does the atmosphere in your classes make you feel like you belong? |
| Experiences of discrimination | Thinking about this semester in the department, overall, how often did you feel treated more negatively than others because you are the member of a particular social group? |
| Persistence | In the last six months how often have you considered leaving the university for reasons other than degree completion? |
| Mental health | To what extent have you felt the following ways over the last month?– sad [. . . excited, stressed, lonely, happy, etc.] |
| Perception of the institution's commitment to diversity | In your view, how committed is the department to diversity and inclusion? |
| Personal values related to diversity | How much do you value diversity and inclusion? |
| Potential target groups | How do each of the following groups affect your sense of belonging in the department?–fellow students [. . . teaching assistants, faculty, academic advisors, tutoring staff, etc. From very negatively to very positively] |
| Problematic behaviors | To what extent do each of the following behaviors negatively affect your sense of belonging in the department?–explicit discriminatory behaviors [. . . social distancing behaviors, use of offensive terms or expressions, etc.] |
| Potential target behaviors | To what extent do each of the following behaviors positively affect your sense of belonging in the department?–being asked to join a study group [. . . being asked to join a social event, someone sitting next to me in class, being asked about my family, someone remembering my name, etc.] |
| Intergroup anxiety | How comfortable do you feel in the department talking to people who belong to a different racial/ethnic group than you? |
| Confronting discrimination | If you were to witness a student discriminating against someone in the department how likely are you to speak up and confront the student? |
| Support for pro-diversity initiatives | How much do you support the Department's pro-diversity initiatives? |
| Self-reported inclusive behaviors | During the current school year, how often have you tried to create a welcoming environment for students from other social groups in the department? |
| Perceptions of descriptive social norms | Based on what you have experienced or witnessed, what proportion of students in the department behave in an inclusive, non-discriminatory way? |
| Enjoyment of diversity | How much do you enjoy having discussions with people whose experiences and backgrounds are different from your own? |

To achieve the second goal–identification of concrete action steps about initiatives to be implemented–the climate survey needs to contain questions that help identify potential target behaviors, potential target audiences, and the barriers and benefits. It is helpful to ask respondents about the groups of individuals that have the most negative impact on their experience in the Department. It is further important to get information about the behaviors that should be discouraged (behaviors that negatively affect the well-being of individuals belonging to marginalized groups) and behaviors that should be promoted in the future (behaviors that make members of marginalized groups feel welcome and included). Once these behaviors have been identified, which will likely be the case after the climate survey has been implemented once or twice in a given Department, it is even possible to include items that measure the barriers and benefits for these behaviors.

As will be described in the next section, one of the most effective ways to promote an inclusive climate is to make salient that inclusion is a social norm. People's perceptions of social norms are determined in part by what their peers think and do, and it is thus important for a climate survey to assess how common inclusive beliefs and behaviors are (the so-called "descriptive norms"). The above-mentioned items measuring personal values related to diversity partially achieve this purpose. In addition, consider including in the climate survey items that measure respondents' support for their department's pro-diversity initiatives, their enjoyment of diversity, their self-reported inclusive behaviors, and their perceptions of the proportion of peers who behave in an inclusive, non-discriminatory way. The survey shown in the online **Supplemental Material** contains additional items that assess respondent's perceptions of the extent to which it is "descriptively normative" to be inclusive. It can be highly effective to create persuasive messages in which the average response to these items is reported. For example, if respondents from marginalized groups answered that a numerical majority of their peers engage in inclusive behaviors and abstain from engaging in discriminatory behaviors, then obviously inclusion is a social norm. As will be explained in more detail in the next section, such "social norms messages" have been shown to promote the occurrence of inclusive behaviors and to promote a welcoming social climate, as long as is it acknowledged that acts of bigotry and exclusion still occur and it is communicated that the department or college will continue its diversity efforts until members of marginalized groups feel just as welcome and included as members of nonmarginalized groups.

## OVERVIEW OF RECENTLY DEVELOPED INITIATIVES TO PROMOTE INCLUSION

A few new approaches to promoting inclusion stand out among the rest. Rather than taking a traditional approach of reducing biased attitudes or raising awareness about persistent prejudice, many of these new initiatives focus on changing behavior. We will discuss in detail two types of interventions, one involving social norms messaging and the other promoting intergroup contact. We will also briefly describe the "pride and prejudice" approach to inclusion in academia. While only some of these initiatives have been specifically tested as ways to improve inclusion in STEM settings, all of them can easily be applied in these settings as they show promise for increasing inclusion in academic contexts.

### Social Norms Messaging

Social norms influence behavior in a way that is consistent with desirable normative behavior (McDonald and Crandall, 2015). Social norms messaging–persuasive messages about social norms–has recently emerged as a promising method for promoting inclusion (Murrar et al., 2020). There are two main types of social norms, descriptive (i.e., what behaviors are common among a group of people) and injunctive (i.e., what is approved of among a group of people; Cialdini et al., 1990). Interventions that utilize messages about descriptive social norms have been used for many years and have been proven successful in a variety of areas (e.g., energy conservation, binge drinking among college students; Frey and Rogers, 2014; Lewis and Neighbors, 2006; Miller and Prentice, 2016). Such interventions influence behavior by changing or correcting individuals' perceptions of their peers' behavior, which is particularly powerful because people rely on each other and their environment for guidance on how to behave (Rhodes et al., 2020).

Prejudice is often blamed on conformity to social norms (Crandall et al., 2002). However, researchers have started to employ social norms messaging as a way to improve intergroup outcomes. For example, Murrar and colleagues (2020) developed two interventions that targeted peoples' perceptions of their peers' pro-diversity attitudes and inclusive behaviors (i.e., descriptive norms) and tested them within college classrooms. One intervention involved placing posters inside classrooms that communicated that most students at the university embrace diversity and welcome people from all backgrounds into the campus community. The other intervention consisted of a short video that portrayed interviews with students who expressed pro-diversity attitudes and intentions to behave inclusively. The video also showed interviews with diversity and inclusion experts who reported that the blatant acts of discrimination, which undoubtedly occur on campus and affect the well-being of students from marginalized groups, are perpetrated by a numerical minority of students. The interventions led to an increase in inclusive behaviors in all students, an enhanced sense of belonging among students from marginalized groups, and a reduction in the achievement gap (see **Figure 2**). Note that Murrar and colleagues' Experiment 6 specifically examined the effectiveness of the intervention in STEM courses.

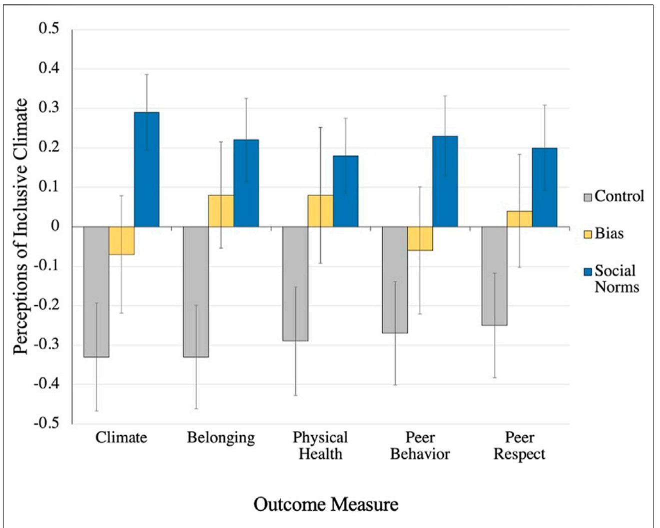


**FIGURE 2 |** Effect of condition on outcomes of interest for students from marginalized groups in experiment 5 of Murrar et al., 2020. Note: The authors compared their social norms intervention to a no-exposure control group and an intervention highlighting bias.

Another intervention strategy that successfully utilized social norms messaging and improved the well-being of college students from marginalized groups was developed and tested by Brauer et al. (in press). Using the steps to designing successful behavior interventions described earlier, these authors identified the target behavior (inclusive classroom behavior), target audience (White university students), barriers (perceptions of peer inclusive behaviors and lack of motivation to behave inclusively) and benefits (importance of working and communicating well with a diverse group of people for others and oneself) to design a theoretically informed intervention strategy: a one-page document to be included in course syllabi. The document included not only social norms messaging about students' inclusive behaviors (descriptive norms), but also statements by the university leadership endorsing diversity (highlighting injunctive norms, Rhodes et al., 2020), a short text about the benefits of learning to behave inclusively (inspired by utility value interventions; Harackiewicz et al., 2016) and concrete behavioral recommendations (inspired by SMART goals; Wade, 2009). This approach of applying multiple theories in an intervention creates "theoretical synergy," which refers to the situation where the elements of a multifaceted intervention mutually reinforce each other and thus become particularly effective (Paluck et al., 2021).

Posters, videos, and syllabi documents are just a few ways through which social norms messaging can be implemented in classrooms to promote inclusive behaviors and improve the classroom climate for students belonging to marginalized groups. Social norms messaging can also be considered a cheap, easy, and flexible way for instructors to shape students' norm perceptions of a classroom early on and establish expectations for inclusive behavior. When inclusive norms are established early, students are more likely to abide by them.

## Intergroup Contact

The intergroup contact hypothesis, first proposed by Allport (1954), has been the basis for many prejudice reduction strategies. The theory suggests that contact between members of different groups can cause prejudice reduction if there is equal status between the groups and they are in pursuit of common goals. Intergroup contact has rarely been tested as a means to promote inclusion in STEM settings, but some recent experiments involving interventions that utilize intergroup contact have shown promise in their ability to promote inclusion and reduce the occurrence of discriminatory behavior.

Described earlier in this paper, Mousa (2020), Scacco and Warren (2018) are examples for how intergroup contact can promote inclusion in academic and non-academic settings. Similarly, Lowe (2021) randomly assigned men from different castes in India to be cricket teammates and compete against other teams. Lowe examined one to three weeks after the end of the cricket league whether intergroup contact experienced through being on a mixed-caste sports team and having opponents from different castes would affect willingness to interact with people from other castes, ingroup favoritism, and efficiency and trust in trading goods that had monetary value. Whereas collaborative contact improved the three outcomes, adversarial contact (i.e., contact through being opponents to different caste members) resulted in the opposite effects.

Lowe (2021), Mousa (2020), Scacco and Warren (2018) intergroup contact interventions show the importance of providing long-term intergroup interactions when trying to reduce discriminatory behavior and promote inclusive behavior. In particular, if the interactions involve being on the same teams and sharing common goals, engagement in inclusive behaviors and decision-making will be a likely outcome. Note that none of these interventions altered people's attitudes. Attitude change is not a precondition for behavior change to occur. Classroom instructors in STEM can leverage insights from the research on intergroup contact by incorporating numerous opportunities for intergroup interaction in the classroom as well as in assignments and projects throughout the course. One easy way to achieve this goal is to form project groups randomly rather than allowing students to form groups themselves.

## Pride and Prejudice

A new strategy for promoting inclusion in academia is the "Pride and Prejudice" approach, which has been created to address the complexity of marginalized identities (Brannon and Lin, 2020). "Pride" refers to the acknowledgment of the history and culture of students from marginalized groups (e.g., classes, groups, and spaces dedicated to marginalized groups), whereas "prejudice" refers to initiatives that address the discrimination experienced by students from these groups. The key idea of this approach is that identity is a source for both pride and prejudice for those belonging to marginalized groups. Both supporting marginalized groups and addressing instances of prejudice are pathways to inclusion in academic settings.

Support for the "Pride and Prejudice" approach comes from Brannon and Lin (2020) analysis of demands made by students from 80 United States colleges and universities compiled in 2016 (see thedemands.org) following a series of racial discrimination protests regarding what changes they wanted to see on their campuses (Hartocollis and Bidgood, 2015). Their analysis revealed that most demands referenced pride experiences and prejudice experiences. Brannon and Lin also analyzed longitudinal data to assess for pride and prejudice experiences among college students in 27 colleges and universities and the relationships of these experiences with several intergroup outcomes. The results showed that pride and prejudice experiences impact students' sense of belonging via ingroup and outgroup closeness. The findings suggest that to promote inclusion in academia, it may be best to create settings that support and celebrate the cultures of marginalized groups in addition to having practices in place to mitigate prejudice and discrimination toward marginalized groups.

# CONCLUSION

A variety of strategies have been developed to reduce the achievement gap (e.g., self-affirmation interventions, promoting growth-mindsets, etc…). However, many of these strategies are meant to help students from marginalized students succeed in an environment that is not inclusive. Instead of placing the burden on students from marginalized groups (i.e., teaching them how to deal with the exclusion and discrimination), researchers and practitioners should shift their focus to creating inclusive academic environments. The research discussed in this article provides a framework for developing successful interventions to promote diversity and inclusion. Such an approach may hold the key to improving the experiences of individuals from marginalized groups by targeting the behaviors that can make them feel more recognized, respected, welcomed, and valued. In the long run this will be the most effective way to raise the success and graduation of students from marginalized groups in STEM.

# AUTHOR CONTRIBUTIONS

GM, NI, and MB participated in the writing and revision of the paper. MB approved the paper for submission.

# SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.668250/full#supplementary-material

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# The Impacts of Global Research and International Educational Experiences on Texas A&M University System LSAMP Participants

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The Texas A&M University System was one of the first six Louis Stokes Alliance for Minority Participation (LSAMP) awardees. All current members of the Alliance are part of the Texas A&M University System. Many high impact practices (HIP) have been emphasized in the Alliance's 30 years of programming with Diversity/Global Learning as a focus in the last 14 years. Diversity/Global Learning has been supported in two formats on the Alliance campuses, through traditional study abroad programming and a College of Engineering initiative. Data presented were derived from a number of sources, project evaluation information regarding student perspectives and outcomes, survey research conducted by an independent party, and institutional data and online platforms accessed to assess student outcomes. Triangulation was completed between data sets. Results indicate both forms of programming were efficacious for underrepresented and first-generation students. Outcomes reported were substantial increases in awareness of and interest in graduate school, increases in cultural learning, confidence in travel outside the United States, learning relevant to major, commitment to continuing involvement with research, interest in another similar experience, and willingness to consider employment outside the U.S. Participants reported statistically significant growth in personal, professional, and research skills. They persisted, participated in additional study abroad experiences, and graduated at higher rates than their institutional peers with approximately 90% of informants indicating intention to consider graduate school in the future, over 40% indicating intent to attend immediately following undergraduate study, and 39.4% of 2007–2014 participants enrolling in graduate school by the spring of 2021.

Programming described is replicable at and likely to be efficacious for a wide variety of institutions of higher education.

**Keywords: LSAMP, high impact practice, study abroad, global learning, underrepresented minority students, first-generation college students, STEM**

## INTRODUCTION

"The Texas A&M University System (TAMUS) Louis Stokes Alliance for Minority Participation (LSAMP) program... [focuses on] encouraging and supporting...underrepresented minority (URM) science, technology, engineering, and mathematics (STEM) majors at ... Alliance member" (Merriweather et al., 2017, p. 1) institutions. "Formally called TX LSAMP, the Alliance was one of the first six LSAMPs funded by NSF" (Merriweather et al., 2017, p. 1) in 1991. Since that time, TAMUS LSAMP has supported over 11,500 students "for one or more semesters of their undergraduate studies" (Merriweather et al., 2017, p. 1) and Alliance institutions have awarded over 22,000 STEM degrees to URMs. "Using a carefully conceived suite of opportunities specially designed for URM undergraduate students...the Alliance has" (Merriweather et al., 2017, p. 1) sought improvement of academic success for underrepresented students. Within the overall emphasis on academic success and advancement, programming offered and the number of member institutions have varied in the last 30 years.

Current TAMUS LSAMP member institutions are Texas A&M University at College Station (TAMU), a Very High Research Activity institution in the Carnegie Classification System (Indiana University Center for Postsecondary Research, n.d.), Prairie View A&M University (PVAMU), an Historically Black College and University (HBCU) (U.S. Department of Education, 2020), Texas A&M University—Corpus Christi (TAMUCC), an Hispanic-Serving Institution (HSI) (National Center for Education Statistics, 2018), and Texas A&M International University (TAMIU), an HSI (National Center for Education Statistics, 2018). TAMUCC's Carnegie classification is Doctoral Universities: High Research Activity. Both PVAMU and TAMIU are in the Master's Colleges and Universities Larger Program category (Indiana University Center for Postsecondary Research, n.d.). The material that follows will include data regarding students from TAMU, PVAMU, and TAMUCC as TAMIU is a recent addition to the Alliance and international programming was prohibited by COVID-19 in 2020.

The material presented addresses a high impact practice (HIP) in higher education (American Association of Colleges and Universities [AACU], n.d.; Kuh and O' Donnell, 2013) that has been emphasized within TAMUS LSAMP. This HIP is Diversity/Global Learning, "courses and programs that help students explore cultures, life experiences, and worldviews different from their own" (AACU, n.d.). Support of international programming became a project objective in 2007. Consciousness of globalization (Smith and Mitry, 2008), the increasingly international nature of engineering practice (Borri et al., 2007; Chan and Fishbein, 2009), and the personal, academic, intercultural, and career benefits reported for undergraduates participating in study abroad programming (Dwyer and Peters, 2005) motivated this action. Specifically, "employability skills such as interpersonal and communication skills, teamwork skills...problem solving and analytical skills" (Potts, 2015, p. 441) were in view as they had been reported "as the greatest perceived benefits" (Potts, 2015, p. 441) of participation in study abroad. "Career-related benefits such as future career prospects and increased motivation and passion for their chosen career direction" (Potts, 2015, p. 441) and intercultural learning (Kamdar and Lewis, 2015; Paras et al., 2019), which had also been identified with study abroad, were other motivating factors. The result was a series of programming emphases that have spanned 14 years.

Two different forms of study abroad programming were found to be efficacious for underrepresented and first-generation engineering students. Outcomes reported were substantial increases in awareness of and interest in graduate school, increases in cultural learning, confidence in travel outside the United States, learning relevant to major, commitment to continuing involvement with research, interest in another similar experience, and willingness to consider employment outside the United States. Participants also reported statistically significant growth in personal, professional, and research skills. They persisted, participated in additional study abroad experiences, graduated, and enrolled in graduate school at higher rates than their institutional and national peers.

## PEDAGOGICAL FRAMEWORK

Three reports have been published that include information about international programming in TAMUS LSAMP. They are, in chronological order: 1) Garcia et al. (2017), 2) Merriweather et al. (2017), and 3) Preuss et al. (2020). The pedagogical framework for TAMUS LSAMP international programming prior to 2015 was not addressed in these publications but that after 2015 has been. A brief description of both frameworks will follow with the description of activity after 2015 referencing the earlier publications.

TAMUS LSAMP's first framework for Diversity/Global Learning was support of individual students in study abroad opportunities they sought out. The second, which continues to the present, was facilitation of a TAMU College of Engineering (COE) initiative offered annually and designed for underrepresented and first-generation students.

Support of study abroad opportunities officially became a project goal in November of 2007. By the summer of 2008 there were five TAMU and two TAMUCC students participating in international experiences in Singapore, Spain, and Mexico. Participation increased at a regular and steady pace from that point forward, with 10 students supported in 2011 in Spain, Mexico, El Salvador, and six locations in Brazil.

To promote Diversity/Global Learning TAMUS LSAMP instituted seminars for participants that described study abroad opportunities. These seminars were offered in two ways. Seminars specific to each Alliance member were held each year and the annual research symposium sponsored for TAMUS LSAMP participants included a presentation about study abroad opportunities. The seminars were intended to increase awareness of study abroad opportunities and included information to help students overcome institutional obstacles and hesitancy on their part or that of their parents, concerns especially relevant to underrepresented and first-generation college students (Brux and Frye, 2010). Evaluation data gathered from students at each institution over a five-year period confirmed the seminars were offered each year and showed that between 67% and 90% of the participants found these sessions at least somewhat helpful.

While seminars about study abroad opportunities continued within the Alliance, emphasis shifted in the 2014–2015 school year to support of the Engineering Learning Community Introduction to Research (ELCIR) program. ELCIR is a one-credit hour, introduction-to-research course that includes "a two-week, study-abroad research program implemented in a learning community pattern. Ten days of international instruction are completed at" (Preuss et al., 2020, p. 1) institutions of higher education in Merida, Yucatan that partner with TAMU. "ELCIR has three purposes: 1) to expose students to research early in their academic careers, 2) to introduce students to cultural differences and global challenges, and 3) to provide students with the basic tools to prepare them for future research opportunities within TAMU's College of Engineering research internship programs, especially study abroad internships" (Preuss et al., 2020, p. 2). Participation during the first two years was "limited to first generation college students and/or students from underrepresented populations who are associated with the Access and Inclusion program in the College of Engineering" (Preuss et al., 2020, p. 2) but was expanded to larger cohorts open to any freshman Engineering student following that.

One distinction between TAMUS LSAMP's initial and later emphasis on Diversity/Global Learning was the age of the participants. Prior to 2015, students funded for study abroad were exclusively juniors and seniors ($n$ = 33). The 2014–2015 transition to supporting student participation in ELCIR included shifting to early career students, freshmen and sophomores. A second distinction between the two periods was the emphasis placed on research as a component of the student's international experience. From 2007 to 2014, students completing international opportunities focused primarily on completing courses at a university outside the United States. Of the 28 students funded for international experiences who provided feedback from 2007 to 2012, all but one reported taking classes but only four reported participating in a research endeavor as part of their time abroad. The one exception to class taking was a student who participated in a summer medical internship and the first report of research involvement as part of a TAMUS LSAMP international experience was four years into the initiative in 2012. ELCIR, though, was conceived as an opportunity that included exposing "students to research early in their academic careers" (Preuss et al., 2020, p. 2).

## LEARNING ENVIRONMENT

Prior to 2015, students were encouraged to participate in study abroad opportunities recognized by their university. These, as has already been noted, were predominantly study at a university outside the United States. Only four of 28 informants in a five-year period participated in a research project as part of their study abroad programming.

In the 2014–2015 school year, TAMUS LSAMP shifted to supporting student participation in the ELCIR program. It "engages students at the beginning of their engineering education in four sets of experiences: 1) a hands-on research class, allowing students to identify their own research problem with the support of faculty and researchers, 2) international travel and two-week residence outside the United States, 3) engagement with highly experienced researchers and well-known research centers, and 4) a [five-page report regarding and] poster presentation of their research proposal results to peers, faculty, and administrators" (Preuss et al., 2020, p. 2). As noted in Preuss et al. (2020), the result is a combination of up to seven HIPs in one program.

"The intention of ELCIR is 'for underrepresented first generation ethnic minority students to be engaged in a research course'" (Garcia et al., 2017, p.2). "Participant selection is based on the student's status as an underrepresented minority and/or as a first-generation college student, his/her grade point average and resume, and a response to a question about what s/he expects to gain from participating in the project. A letter of recommendation from a faculty member [wa]s also requested and considered as part of the participant application" (Preuss, et al., 2020, p. 2) for the first 2 years. Since participants are early in their college careers, faculty could comment on little beyond class performance limiting the breadth of the recommendations and the practice of gathering faculty recommendations was discontinued beginning in ELCIR's third year.

A "one-credit course, ENGR 291 –Engineering Learning Community Introduction to Research, was added in 2016. . .. Inclusion of course credit has been maintained since that time. The initial course consisted of workshops regarding research, global competency, and travel preparation that were conducted with the ELCIR cohort in the spring of their freshman year. It has since been expanded to include more specificity in some areas and to accommodate several additional topics. These include 'introduction of the ELCIR Program purpose and goals, introduction to research topics, introduction to LSAMP/NSF sponsored responsibilities, research and research abroad expectations, [a] seminar on cultural competency, expectations [regarding] living with host families, [and] traveling/departure official documents' (Garcia et al., 2017, p. 3)" (Preuss et al., 2020,

p. 2). The first year ELCIR participants stayed in a hotel but from 2016 on they have been placed with host families to increase cultural learning.

"The two-week international experience is a trip to Merida, Mexico where participants attend an introduction to research seminar (two hours per day), make visits to research sites and participate in research expeditions, receive hands-on experience in research labs, conduct their own research, visit cultural sites, and participate in cultural learning activities. The research course in the summer experience has been taught by 'Dr. Medina-Cetina and the vice president for research of Universidad Marista' (Garcia et al., 2017, p. 4)" (Preuss et al., 2020, p. 2). Growth of the program and expansion of partnerships in Yucatan resulted in the addition of Dr. John Walewski as a facilitator and a second host institution, the Politechnic University of Yucatan in 2017. Also, in 2017, Mexican students were incorporated in the program enabling multi-national student teams in activities and assignments. "Participants can select from a group of topic areas in which to conduct research. These are 'energy, coastal dynamics, logistics, aquifers and early warning system [s]' (Garcia et al., 2017, p. 2) which were chosen because faculty from TAMU collaborate with researchers in Yucatan in these areas" (Preuss et al., 2020, p. 2).

When they return to the U.S., TAMU "participants complete research reports and create research posters based on their investigations in Merida, Mexico. An online community is maintained as part of the project and used as a resource for exchanging materials, offering guidance, and then providing critiques when students are developing their research papers and presentations. Research posters are presented at TAMU COE in September each year" (Preuss et al., 2020, pp. 2–3).

## RESULTS TO DATE

The material presented covers 13 years of programming for engineering students and is based on survey data. Several publications, as noted above, have been completed. The distinctive and notable contribution made here is consideration of 13 years of data rather than two- or four-year segments, inclusion of material from all applicable data sets, data regarding two distinct forms of international experience, consideration of outcomes for upper level and early career students, and presentation of long-term impact on participation in additional study abroad programming, persistence, graduation, and continuation to graduate school. The data included were drawn from project evaluation, with consideration of two different pedagogical frameworks, a research endeavor, and programmatic, institutional, and online student outcomes data. The primary emphasis was on obtaining information about and understanding the cumulative impact of study abroad experiences and ELCIR rather than the impact of various components of these opportunities. Surveys completed prior to 2015 had a participation rate just over 90%. The ELCIR-specific survey responses have a 95% confidence level with a confidence interval of 4.29 as they were submitted by 91 of 110 participants in five distinct cohorts (82.7% response rate).

The information presented is arranged chronologically. Material from before 2015 is presented first. It is based on self-reported data from juniors and seniors after they participated in traditional study abroad programming. That is followed by information provided by ELCIR participants who were almost entirely freshman and sophomores. Data gathering for project evaluation of ELCIR did not include pre-participation processes. However, Garcia et al.'s (2017) investigation of the first two years of programming did. Quantitative data from project evaluation underwent descriptive and tabular analysis while Garcia et al.'s (2017) data could support inferential statistics. Thus, this consideration addresses two forms of Diversity/Global Learning programming for students with similar backgrounds, all from the same institutions. These two populations provided responses regarding many of the same topics. That information is supplemented by insights from Garcia et al. (2017) which discusses a separate data set.

### Study Abroad Programming With Juniors and Seniors (2007–2014)

Three surveys that had the entire TAMUS LSAMP participant population as the audience included questions about the impact of the seminars regarding study abroad. Some of the questions were deployed for two years and others for as many as 4 years.

Responses from two retrospective pre- and post-participation questions appear in **Table 1** (informants were asked to recall and report their pre-participation stance). These questions addressed awareness of international education experiences and interest in them. They were multiple choice questions that employed customized Likert scales. The choices offered to the informants on the first were: 1) never heard anything about (NHAA), 2) only heard a little about (OHALA), 3) had some basic knowledge (HSBK), 4) had some understanding (HSU), and 5) had a good understanding (HGU). These were meant to assess levels of awareness. The choices for the second question, meant to assess interest, were: 1) never heard anything about, 2) not at all interested in (NAAI), 3) a little interested in (ALI), 4) interested in (II), and 5) very interested in (VII).

The customized Likert scales make statistical analysis impossible as the responses are not all related to the same construct and were nominal, for example never heard anything about and not at all interested do not address the same idea or represent a pattern with defined distance between the options. However, the results do indicate changes in awareness and interest resulting from exposure to one or more seminars about study abroad opportunities. More than 77% of respondents felt they had at least some understanding following participation when 24% of them reported this level of understanding as their prior state. Responses for interest were similar with selection of not at all interested dropping by 15.3%, a little interested in dropping by 7.2%, while interested in and very interested in increased by 8.1% and 23.0%, respectively.

Questions specific to the seminars offered at the annual research symposium were also asked. A query that occurred only in 2010 asked how helpful the informants felt information about study abroad and international experiences

**TABLE 1** | Pre- and post-participation awareness of and interest in international educational experiences.

| Topic | *n* | Period | NHAA | OHALA | HSBK | HSU | HGU | NR |
|---|---|---|---|---|---|---|---|---|
| Awareness of international educational/research experiences. | 120 | Before | 10.8% | 35.0% | 29.2% | 14.2% | 10.0% | 0.8% |
| | | After | 0.0% | 5.0% | 15.8% | 34.2% | 43.3% | 1.7% |
| | *n* | Period | NHAA | NAAI | ALI | II | VII | NR |
| Interest in international educational/ research experiences. | 222 | Before | 10.4% | 18.9% | 31.5% | 21.6% | 17.1% | 0.5% |
| | | After | 0.9% | 3.6% | 24.3% | 29.7% | 40.1% | 1.4% |

*Note: NR = no response. The awareness data are from three years. The interest data are from four years. It is possible that some individuals submitted more than one response for each if they were involved with TAMUS LSAMP programming for more than one year.*

**TABLE 2** | Impact of seminars about international education experiences.

| Topic | *n* | NAA | AL | SWT | A lot | AGD | NR |
|---|---|---|---|---|---|---|---|
| Degree to which on campus LSAMP meetings/workshops/seminars contributed to interest. | 173 | 11.0% | 12.7% | 32.4% | 26.6% | 16.8% | 0.6% |
| Degree to which LSAMP symposium workshops contributed to interest. | 104 | 16.3% | 17.3% | 26.9% | 14.4% | 20.2% | 4.8% |

*Note: NAA = not at all, AL = a little, SWT = somewhat, AGD = a great deal, NR = no response.*

**TABLE 3** | Change in perspective reported by study abroad participants.

| Topic | *n* | SD | D | NAD | A | SA |
|---|---|---|---|---|---|---|
| Learned about the culture of the area that I visited. | 28 | — | — | — | 14.3% | 85.7% |
| The experience increased confidence in ability to travel abroad. | 28 | — | — | 3.6% | 3.6% | 92.9% |
| Would consider a job in another country as a result of the study abroad experience. | 28 | 3.6% | — | 7.1% | 21.4% | 67.9% |
| Knowledge and understanding of concepts in major enhanced during the international experience. | 28 | — | — | 7.1% | 28.6% | 64.3% |
| Interested in participating in a similar international experience. | 28 | — | — | 3.6% | 10.7% | 85.7% |
| Able to participate because of the support provided by LSAMP. | 28 | — | — | — | — | 100% |

*Note: SD = strongly disagree, D = disagree, NAD = neither agree or disagree, A = agree, and SA = strongly agree.*

was to them. Forty-six of the 60 participants responded, a 76.7% response rate (95% confidence with a 7.04 interval). Of them, 53.3% felt the seminar was very helpful and 23.4% that it was helpful. An additional 15.0%, 9 persons, found is slightly helpful. While only asked 1 year, almost 92% of the 46 respondents that year reported that the symposium seminar was slightly to very helpful. Responses from two prompts, one focused on the LSAMP programming and the other specific to the symposium seminars appear in **Table 2**. These multiple-choice questions used the same customized Likert scale (see explanation in the table).

Like above, the use of a nominal Likert scale prevented statistical analysis. Yet, the responses from students across four years suggest that the on-campus seminars, which would have been prepared by local personnel and included opportunities specific to the institution, had a greater impact than the general interest sessions presented at the symposium although 61.5% of the informants found the symposium workshops about international experiences contributed at least somewhat to their interest.

A series of six questions was asked of participants from 2010 to 2013 (**Table 3**). This information represents the earliest TAMUS LSAMP efforts to gather specifics about impacts of international experiences. The question set remained uniform for the entire period and the students participating were recruited as juniors and seniors. Four of these questions were retained for 2015 on but, as noted above, the audience and programming experienced were different at that time.

Only one student disagreed at any level with a prompt. That was for considering employment outside the United States. The ratings submitted facilitate a rank ordering by percent agreement. Items with the higher percentage of strongly agree responses were listed first in the case of ties.

1. Able to participate because of LSAMP support (100%). Learned about the culture of area visited (100%).
2. Increased confidence in ability to travel abroad (96.4%). Would like another similar experience (96.4%).
3. Enhanced understanding of major (92.9%).
4. Would consider employment outside the United States (89.3%).

These responses from 28 students across a four-year period support the efficacy of study abroad and, in this case, its effect on LSAMP participants. Many of the students would have been from underrepresented groups but determination of the exact percentage is not possible as ethnic and racial identity information was not solicited on the surveys during this period.

## ELCIR Programming with Freshmen and Sophomores (2015–2019)

From 2015 through 2019, TAMUS LSAMP sponsored involvement in ELCIR. This was also planned for summer of 2020 but prevented by the COVID-19 pandemic. Students participating in the programming were asked a consistent set of questions on a post-participation survey. These included demographic information and 14 other queries. Ninety-one students from a total cohort of 110 submitted responses. The following is a compendium of results from all known sources including previously unpublished material from evaluation data.

### Informant Demographics and Experiential Background

ELCIR survey informants provided demographic data. There were 44 females, 45 males, and two persons who did not categorize themselves. Of these, 82 identified as Hispanic and eight as non-Hispanic (one no response). These individuals thought of themselves as African American ($n$ = 7), Native American ($n$ = 6), Other ($n$ = 8), and White ($n$ = 69) (four no response; Hispanic/Latino was not included as a racial category). When completing the survey in the fall following their summer ELCIR experience, they reported academic classification as freshmen ($n$ = 1), sophomores ($n$ = 80), juniors ($n$ = 8), and seniors ($n$ = 1) (also one no response). Preuss et al. (2020) presents a comparison of these figures to the overall cohort of LSAMP-funded participants in ELCIR programming during the same period. The outcome of that comparison was recognition of informants exhibiting "a slight shift toward females when compared to the overall cohort. The ethnic identity of the survey respondents was similar to that of the overall cohort, the majority of the respondents (89.0%) identified as Hispanic, although this shows there was a slight oversampling of non-Hispanics. The distribution across races was similar…. Overall, the sample parallels the cohort with limited variation which was most pronounced in proportion of females to males, 5% more females in the sample, and in respect to underrepresentation of persons identifying as Native Americans/Alaska Natives" (p. 7).

Participants were asked if they had experience with international travel and study abroad as this had the potential to impact student responses to other queries. Students with prior experience might not confront as many new and challenging realities when participating in ELCIR. Even though the informants were nearly all early career college students (89.0%), 45% of them ($n$ = 41) had traveled internationally. Of those, three (3.3%) had previous experience in a study abroad program. The remaining 47 (51.6%) had no prior experience with international travel. With slightly less than half having traveled internationally the potential for new experiences involved with international travel to impact student responses was reduced.

Another topic of interest in the background of the participants was prior experience in a research setting. While this was not included in the evaluation data gathered from 2015 to 2019, it was part of Garcia et al. (2017) investigation. The question was asked of participants in the 2015 pilot of ELCIR. Fourteen of the sixteen respondents had no prior research experience, one reported one academic semester of research and another two semesters.

Another survey question that informs an understanding of the general orientation of participants to ELCIR programming asked about the student's ability to participate without an LSAMP-provided stipend. This question was added for the 2016 survey and retained for the next three years ($n$ = 81). Informants were asked which of a series of five responses best described what their "participation in an international research experience would have been without the financial support from LSAMP." The five possible answers were: 1) not participate (55.6%), 2) probably not participate (23.5%), 3) might have participated (11.1%), 4) probably participate (3.7%), and 5) would have participated (3.7%). There was also one party who did not respond. Only 7.4% of respondents felt they would have or probably would have participated without receiving financial support.

### Findings Regarding ELCIR Programming

One of the first queries in the surveys from 2015 through 2019 asked for an overall rating of the ELCIR program. This resulted in a strongly positive response with 49 responses of excellent (53.8%), 32 of very good (35.2%), and eight of good (8.8%). Two students did not submit a response (2.2%) and no responses of fair or poor were received. The median and mode values were excellent.

The remainder of the multiple-choice questions asked of ELCIR participants were discussed in detail in Preuss et al. (2020). **Table 4** provides a summary of the findings related to: 1) interest in another similar experience, 2) interest in continued engagement with research, 3) learning achieved regarding the culture of the region visited, 4) increase in knowledge related to the student's major, 5) confidence in travel abroad, 6) impact on interest in employment abroad, 7) impact on career choice, 8) highest degree the student will pursue, and 9) involvement with research post ELCIR. **Table 5** chronicles findings related to graduate school: 1) awareness of, interest in, and plans to attend, 2) view of the affordability of graduate school, and 3) perception of support from family regarding a decision to pursue a graduate degree. For each topic considered in **Tables 4** and **5**, there was no significant difference when comparing responses by gender, ethnicity, race, or prior experience with international travel but measure of the extent of change was not possible as pre-participation data was not gathered.

The responses related to learning and change of perspective can be rank ordered by level of agreement (combining responses of agree and strongly agree).

- Learned about local culture (97.8%).
- Increased confidence in traveling abroad (96.7%).
- Interest in another similar experience (95.6%).
- Encouraged interest in continuing with research (84.6%).
- Enhanced knowledge in major (78.8%).
- Increased interest in employment outside the United States (77.8%).
- Helped with career choice (55.6%).

**TABLE 4 |** Summary of findings from ELCIR surveys 2015–2019.

| Topic | *n* | Finding |
|---|---|---|
| Interest in another international research experience like ELCIR | 91 | 87 of the 91 respondents (95.6%) agreed or strongly agreed; median and mode scores of strongly agree. |
| Interest in continued involvement with research | 91 | 77 students agreed or strongly agreed; median score of agree and mode of agree ($n$ = 40). |
| Learned about local culture during time in Mexico | 90 | 88 of 90 respondents (97.8%) agreed (strongly agree $n$ = 25; agree $n$ = 63). Only two parties did not agree (strongly disagree $n$ = 2). |
| Knowledge enhanced regarding concepts in field in which majoring | 90 | 78.8% agreed (strongly agree $n$ = 32; agree $n$ = 39), 16.7% neither agreeing or disagreeing, and 4.4% disagreeing (disagree $n$ = 3; strongly disagree $n$ = 1). |
| Increased confidence in travel outside the United States | 90 | "Eighty-seven of 90 students. . .Agree or Strongly Agree. . .their ELCIR experience had increased their confidence in traveling abroad" (Preuss et al., 2020, p. 9). |
| Interest in employment outside the United States following ELCIR | 90 | 77.8% agreed (strongly agree $n$ = 47; agree $n$ = 23), 18.9% neither agreeing or disagreeing ($n$ = 17), and 3.3% disagreed (disagree $n$ = 2; strongly disagree $n$ = 1). |
| ELCIR helped with career choice | 90 | "Just over 50% of the students, 47 of 90 respondents, agreed" (Preuss et al., 2020, p. 12); 31.1% neither agree or disagree ($n$ = 28), 13.3% disagree ($n$ = 12), 3.3% strongly disagree ($n$ = 1). |
| Highest degree will pursue | 81 | 72.8% indicated would pursue master's or doctorate. |
| Involvement in UR since ELCIR | 81 | 66 said no but 15 said yes just two months following ELCIR. |

*Note:* n *= 81 occurred for questions that were not asked in 2015.*

**TABLE 5 |** Responses regarding graduate school.

| | | |
|---|---|---|
| Awareness of | 81 | "Responses skewed strongly in a positive direction following ELCIR programming with the median value moving up one category, 80.2% of responses occurring in the top two categories, no responses in the lowest category" (Preuss et al., 2020, p. 10). |
| Interest in | 81 | "Answers skewed positive toward interest in graduate school post-ELCIR. . .all students had heard about graduate school and only six were "Not at all interested. . .". . .a reduction by 28.4 percentage points. The remaining 75 were "A little interested" ($n$ = 22), "Interested" ($n$ = 29), or "Very interested" ($n$ = 24). . . increases of 125% for interested and nearly 250% for very interested" (Preuss et al., 2020, p. 10). |
| Plans to attend | 81 | Post-participation "a total of 91.4% of the participants felt that they might, probably would, or would go to graduate school and 43.2% stated they would go immediately after graduation or at some time in the future. . ..All the other students persisted at their [prior] level of interest or became more interested and none of the students had their level of interest decrease" (Preuss et al., 2020, p. 11). |
| Affordability | 90 | 64.4% agreed or strongly agreed with the statement "I would like to go to graduate school but I just don't see how I can afford it." |
| Family would support decision to go | 90 | 83.3% agreed or strongly agreed their family "would be supportive" of their attending graduate school; the "median response. . .being Agree" (Preuss et al., 2020, p. 12). |

*Note:* n *= 81 occurred for questions that were not asked in 2015.*

Fully 72.8% of these early career minority and first-generation college students indicated intent to pursue a master's degree or doctorate and 18.5% reported immediate continuation with UR.

ELCIR participation also had a strong impact on awareness of and interest in graduate school when retrospective pre- and post-participation ratings were compared (**Table 5**) although the use of a nominal scale prevented anything other than descriptive analysis. Like for the responses regarding highest degree the student would pursue, most of the respondents indicated they would attend graduate school with over 40% stating they would attend immediately after completing their baccalaureate degree. Interestingly, 64.4% of the respondents expressed concern about the affordability of graduate school while 83.3% felt their family would support a decision to pursue a graduate degree.

## Related Measures in Garcia et al. (2017)

### Interest in Research and Graduate School

Garcia et al. (2017) presented ELCIR participants with 14 sentence length descriptions of ways they could engage with graduate school in 2015 and 13 in 2016. Informants were asked to make selections on the pre- and post-participation surveys. In 2015, the "majority. . .($n$ = 14) indicated they planned to pursue a graduate level degree either in the near future or after obtaining some work experience. The remaining two individuals were uncertain about their future plans" (p. 12). The 2016 respondents ($n$ = 37) showed "similar patterns. . .with a shift towards more research-oriented plans after ELCIR took place. Only two individuals had no plans to go to graduate school, and four were unsure" (p. 12).

### Personal and Professional Skills

Garcia et al. (2017) pre- and post-participation survey included 13 elements grouped as personal and professional skills. The skills listed fell in the following domains: 1) leadership, 2) interpersonal communication, 3) networking, 4) communicating technical information, 5) teamwork, 6) personal management, and 7) construction and presentation of written or verbal research summaries. The rating scale for responses was shifted from a five- to four-point pattern between 2015 and 2016. Due to this, data for the 2 years could not be combined.

Ratings submitted by the 2015 cohort ($n$ = 16) showed increases in nine of the 13 areas pre- to post-participation.

The difference in means was statistically significant at the $p < 0.05$ level for one of these, ability "to write a research abstract" (Garcia et al., 2017, p. 9). The authors attributed the general pattern of increase in ratings but few statistically significant differences to high levels of student confidence prior to their international experience.

Pre- and post-participation ratings regarding the same 13 skills were also solicited from the 2016 cohort ($n = 37$). Even though all the pre-participation means were moderately to strongly positive, only four were lower than three (3) on a four-point scale and all the others were between 3.10 and 3.74, there were statistically significant increases for post-participation responses for all 13 at the $p < 0.01$ level. This pattern was interpreted as indicating student growth in all seven areas noted above resulting from project programming.

### Research Skills

Garcia et al. (2017) asked about the student's perceived level of knowledge regarding as set of six research activities. The intention was seeking comparative ratings of "level of knowledge. . .possessed in the area of research they were working on over the summer" (Garcia et al., 2017, p. 7). The six research activities were knowledge of: 1) "the process of research," 2) "the research literature," 3) "the research skills and/or lab techniques," 4) "how to do statistical analysis of research data," 5) "how to interpret research data," and 6) "how to apply research data" (p. 11). Limiting significance to $p < 0.05$, there was one significant finding for 2015. "Students felt that their knowledge of the process of research in their area improved ($p = 0.002$)" (p. 7). For the 2016 cohort, differences between the pre- and post-assessment means were statistically significant for increases in knowledge at the $p < 0.001$ level for all six statements.

### Orientation to and Understanding of Culture

The penultimate topic on Garcia et al. (2017) survey addressed the students' orientation to and understanding of culture. Informants were presented with a list of 19 statements regarding "working and engaging with others of different backgrounds, [and] challenges to their personal beliefs, self-concept, and cultural values" (p. 14). "For the 2015 cohort, there were no significant changes from pre- to post-test. . .. The 2016 cohort, however, had many significant differences in their post-test results compared to their pre-test results. . .. This may be due to. . .students in this cohort stay [ing] with local families. . .whereas the 2015 cohort. . .stayed in hotels. This may have had a greater impact on. . .cultural perspectives" (Garcia et al., 2017, p. 14).

## IMPACT ON ACADEMIC OUTCOMES AND PERSISTENCE

Garcia et al. (2017) attempted to use Grade Point Average (GPA) as a means of assessing academic impact of ELCIR participation. They compared GPA from the semester preceding the summer experience to that at the end of the semester immediately following it. "There were no significant differences between the two cohorts' overall GPAs from one semester to the next, [but] both [cohorts] demonstrated improvement" (p. 18). Given the level of the GPAs involved, annual averages near or slightly above 3.0, the potential for a substantial improvement in one semester was limited.

The 2017 study also considered persistence. "The retention of both cohorts in the College of Engineering at Texas A&M University [w]as. . .remarkable" (p. 18).

- 96.0% of the 2015 cohort and 88.0% of the 2016 participants retained majors in Engineering (Garcia et al., 2017).
- 100% of 2015 and 88.0% of 2016 participants persisted through their next year as TAMU students (Garcia et al., 2017) when the historic second year persistence rate for TAMU first-time-in-college Engineering students was 86.7% between 2015 and 2018 (Texas A&M University, n.d.).

Graduation and persistence data for all LSAMP-supported ELCIR participants between 2015 and 2019 confirm high retention rates and, for the two years for which it is possible, higher than average graduation rates.

- One- and two-year retention rates for the cohort were 97.3% and 93.0%, respectively, while for their peers in Engineering they were 92.6% and 87.4% (Texas A&M University, n.d.).
- Six-year graduation rates for former participants were 92.3% when the TAMU rate for undergraduates in the same period was 82.6% (Texas A&M University, n.d.).

Student tracking also confirmed higher than average engagement with study abroad programming post-ELCIR, and high levels of graduate school enrollment.

- Forty-one of the ELCIR participants (37.3%) completed a second study abroad program yet the Open Doors Report on International Educational Exchange indicated only 6% of engineering students completed study abroad experiences during the same time period (opendoor, n.d.).
- Graduate school enrollment was also high. Thirteen of 33 students (39.4%) in the 2007–2014 group attended graduate school resulting in nine master's degrees, a PhD, an MD, and two other parties active in graduate study at the time this report was written.
- Seventy-two of the 2015–2019 ELCIR participants completed bachelor's degrees by the time of publication with seven enrolled in or having completed graduate study. Twenty-nine were still TAMU undergraduates and nine were no longer studying at TAMU.

## DISCUSSION

The findings parallel the benefits noted in the literature that were the basis of planning the initiatives. They were consistent for traditional study abroad programming facilitated for junior and seniors and for programming with freshman and sophomores as the audience.

- Seminars were noted as contributing to student interest in international educational experiences with those prepared and presented by local university personnel showing slightly higher impact.
- Students at all academic levels reported substantial increases in awareness of and interest in graduate school.
- Students at all academic levels and on several different measures reported increases in cultural learning, confidence in travel outside the United States, learning relevant to their major, commitment to continuing involvement with research, interest in another similar experience, and willingness to consider employment outside the United States.
- Approximately 90% indicated intention to consider graduate school in the future with over 40% indicating intent to attend immediately following undergraduate study and 39.4% doing so in the 6 years following participation.
- 37.3% of ELCIR participants completed a second study abroad experience as undergraduates.
- Participants persisted and graduated at higher rates than their institutional peers.

The outcomes are likely related to the growth in personal, professional, and research skill reported by participants. The areas in which there was the least impact, career plans and immediate continuation with undergraduate research (UR), were measures taken with early career students in the semester following the international experience. It is possible that a significant number did not have firmly established career plans and that there was limited motivation to initiate a new course of UR while completing the final requirements of the ELCIR program. Having 18.5% of the students continue with UR immediately is positive as "approximately 25% of TAMU engineering students participate in UR prior to graduation" (Preuss et al., 2020).

The TAMUS LSAMP findings included no statistically significant differences regarding student experience, learning, or perspectives when compared by gender, ethnicity, race, and prior experience with international travel. This is a notable confirmation that the programming described was efficacious for college students from underrepresented groups, many of whom were first-generation college students who may also have had limited resources. The vast majority of the students indicated they would not have been able to participate without financial assistance and nearly two-thirds indicated uncertainty regarding whether and how they could afford graduate school. Yet, it is also notable that over 84% of informants, who were predominantly URM students with 91.1% identifying as Hispanic, felt their family would support pursuit of a graduate degree as this does not align with historic patterns in STEM graduate programs and employment (Bayer Corporation, 2012; Linley and George-Jackson, 2013; Collins, 2018; NSF, 2018).

That these findings existed for URM students early in their academic careers and as juniors and seniors, across thirteen years of activity, with students attending Minority-Serving Institutions and a Predominantly White Institution (PWI) with differing Carnegie classifications, and for two different Diversity/Global Learning frameworks distinguishes this material from that describing other efforts. As a combined set, the data demonstrate substantial impact on participant perspective, interest, intention, and learning as well as suggesting a connection to high levels of persistence, continuing engagement with Diversity/Global Learning programs, degree completion, and enrollment in graduate school.

## IMPLICATIONS

There are several simple implications of the findings. First, both traditional study abroad programming and structured programming including short-term involvement in research in an international setting were efficacious with LSAMP participants. Programming of either type is likely to have similar results at other institutions as the TAMUS participants came from a PWI, an HBCU, and an HSI that have different Carnegie classifications. Second, both types of programming were effective with students from underrepresented groups and who were first generation college students. Third, the year in school of the participant does not appear to influence the potential for substantial benefit from the programming, although this is a generalization based on different age groups reporting similar results to the two different approaches rather than samples of students at every level of undergraduate study experiencing both approaches. An important caveat, though, is the ability of an institution to provide stipends to enable student participation as this was a primary component in both approaches enacted by TAMUS LSAMP.

Replication of the initial pedagogical framework is possible for many institutions. Identifying funds for participant stipends would be the most challenging element. Sponsoring personnel could use existing study abroad programming as the platform and collaborate with their study abroad office in refining informational and orientation seminars for participating students. Replication of ELCIR requires funding to support participants, creation of a one-unit course, identification of and program planning with an institution of higher education outside the United States, and planning and implementing pre- and post-participation seminars and processes. Garcia et al. (2017) and Preuss et al. (2020) provide additional details as can authors of this publication. While substantial institutional and time commitment would be required to initiate and maintain such an effort, it may be more possible for institutions near the international borders of the United States and the potential for long-term societal impact demonstrated by the pronounced and positive outcomes for URMs has a strong appeal in light of the known need for persons with STEM degrees and patterns of underrepresentation in the STEM workforce of the United States employment (Bayer Corporation, 2012; Linley and George-Jackson, 2013; Collins, 2018; NSF, 2018).

## LIMITATIONS

The data came as student self-reports and addressed experience, self-assessment, and personal opinions. Control groups were not included. Thus, the majority of information considered herein is descriptive. Inferential analysis was limited to one data stream, although those findings corroborated and elucidated the descriptive analysis. The sample sizes were moderate, less than 100 persons. The findings are then, primarily, a descriptive case study of two patterns of Diversity/Global Learning programming. Support from other sources and through further investigation by TAMUS LSAMP will be necessary to establish more robust evidence of efficacy.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the data include responses from a small number of participants. This could make information individually identifiable. Requests to access the datasets should be directed to exquiri.michael@gmail.com.

## ETHICS STATEMENT

The studies involved human participants and were reviewed and approved by the Texas A&M University Institutional Review Board. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individuals for the publication of any potentially identifiable images or data included in this article.

## AUTHOR CONTRIBUTIONS

First authorship is shared by MP, SM, and JA. MP compiled applicable data from evaluation materials, completed quantitative data analysis, planned and led group analysis of qualitative data, completed secondary research, and drafted the article. SM and JA coordinated data gathering from partnering institutions and completed analysis of those data, completed data gathering and analysis specific to TAMU, helped plan the presentation, and provided comments on drafts. Senior authors are KB-P, KW, SW, PO, FP, JM, and MR. They coordinated site-specific activity and commented at different points during development of the article. JK, HL, MA, and SG are last authors. JK and HL planned and conducted evaluation processes that resulted in data presented in the article. MA and SG coordinated the ELCIR efforts, approved use of content from their 2017 publication, gathered institutional data, and commented on descriptions of ELCIR in this article.

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# LSAMP-NICE: Expanding International STEM Research for Underrepresented Minorities

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**Background:** The global challenges of climate change, disease and hunger exceed national borders as do possibilities of sustained life, exploration and economic development in outer space. Both help to underscore the need for sustained international STEM research to leverage the talent embedded in different countries and in diverse groups within countries. This study focuses on the United States National Science Foundation provision of funds to its Louis Stokes Alliance for Minority Participation (LSAMP) Program to create a National Center of Excellence LSAMP-NICE for the establishment of international STEM Research Partnerships with a particular emphasis on the integration of international collaborative research for underrepresented minority STEM faculty, students and graduates. The study focuses on the diffusion of this Center's services to the LSAMP Community, a group of 56 LSAMP funded STEM enrichment programs located across the United States. We found that LSAMP-NICE used mass media (a website and two advertorials in a national journal) and an annual national meeting as its major diffusion strategies during its first two years. Forty-two (42) programs responded to the questionnaire. The majority of the respondents (71.4%) had not used the website; 88.1% had not read the Advertorial in Science Magazine; and 78.6% did not attend the national 2019 LSAMP-NICE Annual Meeting in Washington, D.C. Our study suggests a need for additional diffusion techniques to reach the intended audience. Some respondent suggestions for diffusion include participation by LSAMP-NICE representatives at LSAMP Regional Conferences and Symposia, visits by LSAMP-NICE staff to LSAMP programs, forging relationships with higher education institutions abroad so LSAMP students can obtain summer or longer-term research experiences and providing technical assistance on applying for international travel funds.

**Keywords: diversity, international, partnership, diffusion, STEM, alliances, research, innovations**

## INTRODUCTION

The National Science Foundation (NSF) has funded the Louis Stokes Alliance for Minority Participation (LSAMP) International Center of Excellence since 2018[1] to help ensure a well-prepared cadre of underrepresented STEM scientists representing America's contribution to the global society's knowledge base in addressing the health, safety, security and environmental well-

[1]National Science Foundation, September 1, 2018, NSF Proposal Number 1826824, HRD—Alliances-Minority Participation.

being of humanity. For 30 years of funding, LSAMP has built a nationwide group of Alliances focused on broadening STEM participation of underrepresented minorities at college and university campuses including Historically Black Colleges and Universities, Tribal Colleges, Traditionally White Institutions and institutions serving other minority populations including Native Pacific Islanders and Alaskans. During the period of data gathering, there were fifty-six Alliances[2] which are referred to in this study and in the STEM professional community as "The LSAMP Community." In 2018, in response to the recommendation of the Project Director, Dr A. James Hicks and a review panel, the National Science Foundation funded the Louis Stokes Alliance for Minority Participation NSF International Center of Excellence. The goal of the Center is to help increase the number of STEM international research partnerships for United States underrepresented minority faculty, students and post-doctoral alumni. This exploratory study was designed to describe the diffusion strategies used by LSAMP-NICE and the use and adoption of the Louis Stokes Alliance for Minority Participation NSF International Center of Excellence enhancement strategies by the LSAMP Community. The study is grounded in Everett Roger's theory of the diffusion of innovations[3] which explains how and why innovations or new strategies are or not embraced. LSAMP-NICE is conceptualized as an innovation supported by NSF LSAMP to serve as a connecting and facilitating link between United States colleges and universities, especially those with LSAMP-funded programs, and international universities and laboratories with strong STEM research portfolios and an interest in international research partnerships. LSAMP-NICE is also tasked to serve as point of contact in the United States for international colleges, universities and laboratories who are interested in partnering with United States researchers and institutions. The focus of this study is on LSAMP-NICE as a resource to the LSAMP Community in facilitating and increasing the number of active international research partnerships which can result in an increase in the number of United States underrepresented minority STEM faculty, students, and post-doctoral graduates who enhance their STEM knowledge, research skill and appreciation for the value of global STEM research.

## Theoretical Framework

This study is grounded in innovation and diffusion theory. Everett Rogers is a pioneer in the United States in the development and advancement of this theory (Rogers, 2003). He first used this theory to study acceptance of hybrid corn by Iowa farmers and later to study areas such as health care promotion. Today this theory is being used in marketing and commercialization. Rogers outlines key characteristics of the new or innovative concept that impact the targeted groups' acceptance of the innovation. These include relative advantage, compatibility, complexity, trial ability and observability of the innovation (Rogers, 2003). Implicit in this typology is the potential adopter's perception of the gains from adapting the new concept or practice, the fit of the innovation with the adopter's existing practices and values, the potential gain such as improved standard or living or market expansion, the difficulty in implementing the new approach. the need to sample or "try out" the proposed product or concept and finally actually witnessing the adoption of the innovation and the outcome for others. Rosen focused on the impact of the personal communication process in diffusing innovations (Rosen, 2009)[4]. He emphasized the importance of 'Word of Mouth" communication in diffusing new concepts. Labeled 'The Buzz," attention is focused on the importance not only of what is being said but also on who within the trusted groups is endorsing or rejecting the new concept. In "Theories of Innovation Adaptation and Real World Case Analyses." Marcia Ham uses Everette Rogers' theory of innovation as the basic theoretical framework. Her emphasis is on the adoption of technology in higher education. Her study offers a contemporary example of innovative ways that business and higher education can create and diffuse new opportunities for educational achievement by students who may be challenged by the cost of higher education, who take jobs to help pay for their education and who eventually drop out because of the competing time demands. Ham's description of the Starbuck College Achievement Plan in collaboration with Arizona State University (ASU) offers an example of an innovative concept and its diffusion. The plan, as it emerged, added the Starbuck Pathways to Admissions with ASU (an innovation) for those students who were having difficulty meeting the university's admission standards and diffused this opportunity to the Starbuck employees thus paving the way from them to enter and compete in more than seventy on-line degree programs. From the review of innovation models, Ham concluded that the commonality of variables most likely to influence the acceptance or rejection of the innovation are socio-political and external factors such as environment, policies, regulations, social networks organizational characteristics such as leadership, social climate and organizational structure; and innovation characteristics such as complexity, compatibility and trialability (Ham, 2018)[5]. In this study, the National Science Foundation Louis Stokes Alliance for Minority Participation (LSAMP- NICE) Center of Excellence is conceptualized as an innovation in the area of fostering an increase in the number of international research partnerships for NSF LSAMP funded undergraduate and graduate Science, Technology, Engineering and Mathematics (STEM) research training programs focused on underrepresented minorities and administered by 56 LSAMP Alliances located across the United States of America. This study is focused on the diffusion process used by the LSAMP-NICE Center of Excellence as an innovation and the adoption of the Center's

[2]https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13646

[3]Rogers, Everett (2003). Diffusion and Innovations. Fifth Edition. Free Press.

[4]Rosen, Emanuel (2009). The Anatomy of the Buzz Revisited. Doubleday.

[5]Ham, M. (n.d.). Theories of innovation adoption and real-world case analyses. In Correia, A. (author), *Driving educational change: Innovations in action.* Pressbooks. https://ohiostate.pressbooks.pub/drivechange/

strategies by the LSAMP Community from 2018 to December 2020.

## METHODOLOGY

A nine- item questionnaire was used for data collection. The LSAMP Alliances were identified by querying the NSF website at https://nsf.gov/awardsresearch/October 2019 for currently funded NSF-LSAMP Alliances. Also, the LSAMPCommunity@LISTSERV.NSF.Gov was used to further identify the LSAMP Community. Through this process, 56 LSAMP Alliances were identified and were emailed the nine-item survey. Forty-two (42) non-duplicative responses were received. The questionnaire (see **Supplementary Material**) included background information including name of the college or university, identification of P. I. or person completing the questionnaire, years of NSF LSAMP funding, type of program (Bridge to Doctorate and/or Baccalaureate), list of current international partnerships, knowledge of the LSAMP-NSF International Center of Excellence and LSAMP principal investigators' suggestions on ways that the Center can help their LSAMP Programs develop and formalize more international STEM research partnerships leading to expanded collaborative research.

### The Sample

The LSAMP respondents reflect an experienced group of NSF-LSAMP funded program administrators. More than half (55%) of the sample of 42 reported from 16–30 years of experience in LSAMP program delivery. The sample also included professionals with developing experience in LSAMP program delivery. For example, nearly 12% of the sample (N = 5) had from 1 to 5 years of experience in LSAMP program delivery. This could reflect a newly funded program or a newly appointed P.I. **Supplementary Table S1** depicts the range of leadership by years of experience in NSF-LSAMP funded program delivery for the members of the LSAMP Community who participated in this study. (See **Supplementary Table S1**). In this study, the majority of the programs (61.9%) were funded for the NSF LSAMP Bridge to the Doctorate Programs. Bridge to Doctorate (BD Activity) are projects that focus on providing post-baccaulaureate fellowship support to cohorts of 12 LSAMP students from underrepresented minority populations for successfully earning STEM doctoral degrees and transition into the STEM workforce. Only institutions in well-established alliances, funded for 10 or more consecutive years, are eligible for this funding opportunities. These are 2-year awards.[6] The large percentage of LSAMP Bridge to the Doctorate programs in this sample (See **Figure 1**) is indictive of the wealth of experience amassed by NSF LSAMP funded program administrators while delivering undergraduate NSF LSAMP STEM enrichment programs and subsequentially leveraging that experience to successfully develop a Bridge to the Doctorate proposal that was funded by NSF-LSAMP.

[6]https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13646

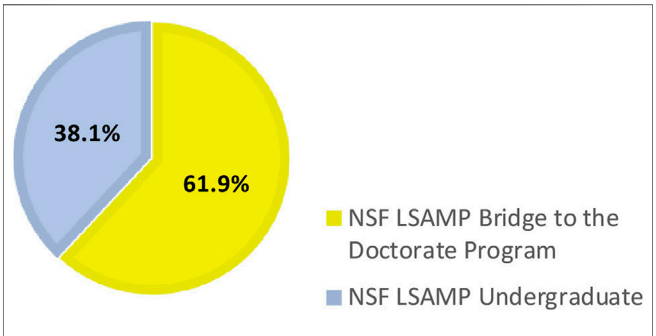


**FIGURE 1 |** LSAMP Community respondents by percent and type of NSF-LSAMP funded programs.

## ANALYSIS OF DATA

The focus of this study was to examine LSAMP Community awareness and use of the Louis Stokes Alliance for Minority Participation NSF International Center of Excellence (LSAMP-NICE) to increase their number of international partnerships for STEM research. Data are presented on awareness and use, along with recommendations from the LSAMP Community on strategies that the Center could use to increase utilization of its services and thereby potentially increase the number of international research partnerships for the LSAMP Community.

## AWARENESS OF LSAMP-NICE

LSAMP-NICE, an NSF funded program established in 2018, is conceptualized as an innovative concept designed to help increase the number of international research partnerships with an emphasis on underrepresented minority faculty, scientists, students and post-doctoral alumni, who are products of NSF-LSAMP funded colleges and universities STEM enrichment programs. No other NSF National Center has this specific charge. Three major strategies were used by LSAMP-NICE to introduce this innovative concept to the LSAMP Community. Included were a website, an annual national meeting and two advertorials in SCIENCE Magazine. The respondents' use of these three introductory and information diffusion strategies are presented in **Figures 2**, **3**, and **4**.

The LSAMP-NICE Website (http://lsamp-nice.org) (See **Supplementary Material**) was designed as a repository of information for the LSAMP Community and the scientific community at large. There was to be a database of collaborative research opportunities and resources with links to international collaborative partners providing information and resources.[6] At the time of this study in Fall 2020, the majority of the LSAMP Community respondents had not used the website. Just over one-fourth (28.6%) of the respondents had used the LSAMP-NICE Website compared to slightly over 70% (71.4%) who had not used the website (see **Figure 2**).

The partnership with Science Magazine was meant to expand the reach of information highlighting collaborative international research activities and successes in STEM as a result of LSAMP-NICE partner resources availability. The Science Advertorials

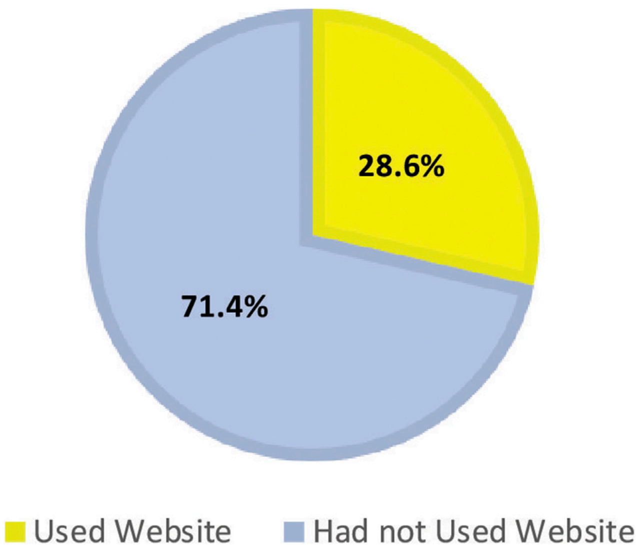


**FIGURE 2 |** LSAMP Community respondent's reported use of the LSAMP NICE Website by percent.

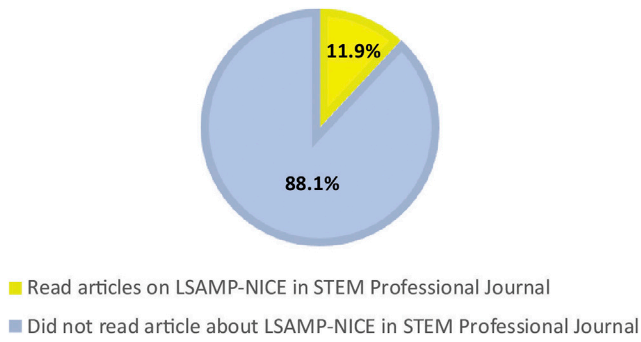


**FIGURE 3 |** LSAMP Community respondents by percent and reading of article on LSAMP-NICE in professional STEM magazine.

published in April 2020 and September of 2020 were paid publications presenting evidence of faculty and LSAMP student engagement in international collaborative research. SCIENCE Magazine online readership is highlighted in **Supplementary Material S2**. The majority (88.1%) of the LSAMP Community respondents had not read about LSAMP-NICE in the SCIENCE Magazine, the professional journal where the two LSAMP-NICE advertorials were published.

LSAMP-NICE International Center of Excellence First Annual Meeting was designed to introduce LSAMP-NICE to the LSAMP Community and to potential international STEM collaborative research partners and to simultaneously introduce the LSAMP Community to LSAMP-NICE. By poster exhibits, student and faculty STEM research underway at LSAMP Community colleges and universities was presented to inform LSAMP-NICE and the visiting international researchers and research administrators of current STEM research underway. The Annual Meeting was held in September 2019 at the Embassy of France in Washington, D.C. Sixty-five persons were in attendance including researchers and research administrators from France, Panama, Saudi Arabia, South Africa and Taiwan along with representatives from the National Science Foundation and some regional alliances. (See **Supplementary Materials S3**). The majority of the LSAMP Community respondents in this study (78.6%) were not in attendance (See **Figure 4**).

## EXISTING LSAMP COMMUNITY INTERNATIONAL STEM PARTNERSHIPS

Central to this study was gaining insight on the number of international STEM research partnerships currently existing in the LSAMP Community which serves underrepresented minority STEM students and, if needed, to map strategies to increase this number. Thirty-seven (37) respondents replied to the question on the number of international STEM research partnerships. Nearly half, 48.6%, of the respondents reported having international STEM research partnerships with the number of these partnerships ranging from one to ten (1–10). Nearly one-third (29.7%) of the respondents did not have any international STEM research partnerships. Two respondents reported emerging international STEM research partnerships (see **Supplementary Table S2**). This data can be useful to LSAMP-NICE in expanding the number of international STEM research partnerships by tapping the knowledge and skills of leaders of those Alliances with existing partnerships in developing and delivering regional workshops and offering consultation to Alliances on strategies that are useful and effective in building international STEM research partnerships. Consideration should be given to the size and composition of the Alliances in terms of number of participating institutions, varying missions (community college, baccalaureate, graduate, Tribal, HBCU and institutions that enroll large cohorts of Native Alaskan and/or Pacific Islander students) which can impact an Alliance's number of international STEM research partnerships.

Overall, the data showed different strategies used by the Alliances to establish their international research partnerships or international research opportunities. For example, the WiscAMP (Wisconsin LSAMP) does not have partnerships with international research institutions. However, this Alliance works with the University of Wisconsin-Madison Office of International Programs to connect their students to international research opportunities. Many of their students, through the WINStep Program, have done research in India with the Government of India scientific agencies and with universities in India. The majority of the Alliances reported that they worked directly with their international partners to establish their research partnerships. The expansion of the number of international STEM research partnerships is critical for the realization of the goal of the LSAMP-NICE and for the advancement of global collaborative scientific research. The data from this study (See **Supplementary Table S2**) can be used to identify where assistance is needed and identify LSAMP Community principal investigators with proven success in establishing international research partnerships and who can

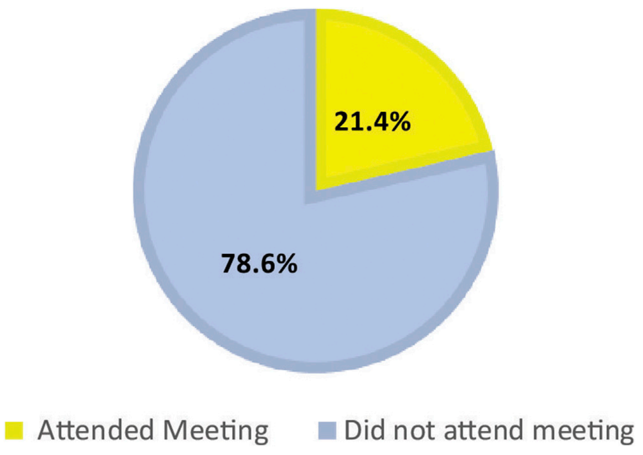


**FIGURE 4 |** LSAMP Community respondents by percent who attended the first annual LSAMP-NICE meeting September 2019.

provide consultation and guidance to alliances who may want to establish or increase their international STEM research partnerships. The linkage of LSAMP- NICE with this leadership group could provide a readily accessible cadre of LSAMP Community knowledgables who can help diffuse (Rogers 2003) workable strategies on international partnership development which will be embraced by the LSAMP Community. This can help more underrepresented minorities to gain STEM international research experience, LSAMP-NICE to achieve its primary goal and could expand the body of knowledge in STEM research, internationally.

## Introduction to LSAMP-NICE

Respondents were asked how they learned about LSAMP-NICE. Twenty-four responded with answers including visits by the former LSAMP-NICE principal investigator to their Alliance, information from a current LSAMP-NICE CO-PI, networking with colleagues, and having an LSAMP student participate during the 2019 LSAMP-NICE Annual Meeting (See **Supplementary Material S1**). All responses reflect direct interaction with individuals knowledgeable of LSAMP-NICE which enhanced the LSAMP-NICE diffusion process.

## How LSAMP-NICE Can Be Helpful to Alliances:

Respondents were asked to share their ideas on how LSAMP-NICE can be helpful to them in forging more international STEM research partnerships (see **Supplementary Material S1**). Thirty-seven participants replied. The answers included 1) "everything," 2) forging relationships with institutions abroad so that their students can pursue summer and long-term research experiences hosted by those institutions. 3) becoming a partner with LSAMP programs, 4) assisting in finding research experiences for students in Alliances in the Pacific Region, especially those from two-year colleges where faculty often have major teaching responsibilities and limited time for research; 5) assist in writing proposals for an IREU or IRES and 6) provide technical assistance on applying for international travel funds. The respondents' willingness to share the type of assistance that they need from LSAMP-NICE or that LSAMP-NICE can help broker for them are compatible with the overall purpose of LSAMP-NICE. This compatibility of the LSAMP Community's purpose and strategies with LSAMP-NICE's purpose creates fertile ground for collaboratively partnering to increase the number of international STEM research partnerships through using more in-person diffusion strategies and by engaging very successful LSAMP Community P.I.s to share their own as well as the LSAMP-NICE strategies to help increase the number of international STEM research partnerships.

# CONCLUSION

This exploratory study was conducted to describe the services provided by LSAMP- NICE, a National Science Foundation (NSF) funded Center of Excellence, to the LSAMP Community, a group of 56 NSF funded Alliances located on college and university campuses to deliver STEM research enrichment programs to underrepresented college and graduate students. The Center's primary purpose is to help the Alliances increase the number of international STEM research partnerships and thereby increase the number of underrepresented minority students, graduates and faculty who gain the benefit of an international perspective on their research while also broadening their pool of STEM colleagues.

We found that LSAMP-NICE's major outreach and strategy to diffuse information to the Alliances was by digital and mass media including a website, an advertorial in two issues of a science related journal and an annual national meeting. We found that most respondents had not used these resources and concluded, after reading respondents' recommendations, that the Center of Excellence should consider adapting more in-person and targeted strategies to diffuse its services. We also found a rich reservoir of talented Alliance program directors within the respondent group in terms of their success in developing international STEM partnerships; however, they were in the minority. We concluded that these Alliance project investigators could be engaged by the Center of Excellence to mentor and consult with those Alliances who have none or few (1–3) international STEM partnerships. From recommendations made by Alliance respondents, we concluded that when planning workshops and in-service sessions for and with Alliance groups, attention should be given to regional differences within the alliances, size of the alliance, as well as the number of years with NSF LSAMP funding. We also found, from responses to open-ended questions, that among those respondents who knew about the overall service of LSAMP-NICE, most had learned from a personal visit by the LSAMP project director, information from a Center of Excellence co-project director, or from a colleague . . . all underscoring the impact of "The Buzz" (Rosen, 2009) and personal contact in diffusing the Center of Excellence's purpose and services. Respondents from two-year colleges shared a need for the Center to offer recommendations on how to engage 2-year colleges, faculty, and students in international collaborative research given the special mission of two-year colleges. We also concluded that the workshops to diffuse the LSAMP-NICE concept and services should be planned in consultation with the respective Alliance groups. Topics should include 'Strategies in Building International STEM Research Partnerships as well as assistance in developing fundable proposals to help underwrite the embedded and cost prohibitive expenses associated with international programming and travel.

Finally, we concluded that LSAMP-NICE has a clear and needed goal which is to help increase the number of international partnerships for the NSF-funded LSAMP Alliances and in doing so help to increase the pool of underrepresented minority STEM students, faculty and graduates who can expand their network of collaborators, add international research experience to their portfolio, and contribute to the STEM international database.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Richard Walker, University of Arkansas at Pine Bluff. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

## AUTHOR CONTRIBUTIONS

MB was responsible for the conceptualization of the research proposal, design of the survey instrument, analysis of data and writing of the article. She was also responsible for identifying the research assistants and for maintaining contact, jointly and individually, with the Co-PIs. DY was the sounding board as the problem was conceptualized, shared her extensive knowledge of the LSAMP Community and during the analytical stage shared her rich background in building STEM international research MOUs and partnerships. She was critical in helping to identify databases from which the study group was drawn. Her proofreading was an asset. SD is an experienced LSAMP program director and the current P.I. for LSAMP-NICE. His commitment to the goal of LSAMP-NICE and his willingness to endorse this exploratory research were assets as we launched the data gathering process. His use of the findings and conclusions from this study could be beneficial in building a larger and more diverse group of United States underrepresented minorities with STEM international research experience.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.668232/full#supplementary-material

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# Improving Academic Self-Concept and STEM Identity Through a Research Immersion: Pathways to STEM Summer Program

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Undergraduate research opportunities have been demonstrated to promote recruitment, retention, and inclusion of students from underrepresented groups in STEM disciplines. The opportunity to engage in hands-on, discovery-based activities as part of a community helps students develop a strong self-identity in STEM and strengthens their self-efficacy in what can otherwise be daunting fields. Kansas State University has developed an array of undergraduate research opportunities, both in the academic year and summer, and has established a management infrastructure around these programs. The Graduate School, which hosts its own Summer Undergraduate Research Opportunity Program aimed at URM and first-generation college students, coordinates the leadership of the other grant-funded programs, and conducts a series of enrichment and networking activities for students from all the programs. These include professional development as well as primarily social sessions. The Kansas LSAMP, led by Kansas State University, created a summer program aimed at under-represented minority community college students enrolled in STEM fields to recruit them into research opportunities at K-State. There has been strong interest in the program, which incorporated university experience elements in addition to an introduction to STEM research and the four-year university. In the 5 years since the program's inception, cohorts of nine to fourteen students came to K-State each year for eight-week experiences and took part in both cohort-based sessions and individual mentored research experiences. The two-fold focus of this program, Research Immersion: Pathways to STEM, has resulted in the majority of the students presenting a poster at a national conference and transferring to a STEM major at a four-year institution. Survey results showed that the program was successful at improving STEM identity and academic self-concepts. Qualitative feedback suggested that the two parts of the program worked together to increase interest and self confidence in STEM majors but also ensured that students connect with other students and felt comfortable in the transition to a 4-year institution.

**Keywords: summer research experience, community college, academic self concept, science STEM identity, STEM recruiting**

## INTRODUCTION

The United States faces continued need for graduates in science, technology, engineering and math (STEM) to address national and global challenges in energy, medicine, infrastructure, computer technology and other STEM fields (The National Academy of Sciences, 2011). While the need for STEM graduates is strong, student attrition remains high in STEM degree programs (National Center for Education Statistics, 2013). Further, underrepresented minority (URM) students represent a small percentage of students completing STEM degrees (DePass and Chubin, 2008). STEM degree granting institutions have developed STEM intervention programs (SIPs) such as mentoring, tutoring, and research opportunities to improve retention through support and engagement of students, particularly underrepresented minority students (George-Jackson and Rincon, 2011). Research into the impact of SIPs is limited. Researchers have called for studies of the efficacy and impact of these programs on URM students (Dyer-Barr, 2013).

Undergraduate research provides students an opportunity to engage in the process of scientific discovery and get insight into what a science career might entail. Reports from students highlighted personal and professional gains, the ability to "think like a scientist" and a shift in attitude toward learning and working as a researcher (Seymour, 2004). While undergraduate research can occur during the academic year, summer undergraduate research allows for students to engage in the process full-time. Summer programs have been shown to enhance the educational experience of undergraduate students as measured by learning gains related to the research process, readiness for more demanding research and understanding how scientists work on real problems (Lopatto, 2004; Lopatto 2007). Additionally, student benefits include increased interest in their discipline, enhanced career preparation, gains in critical thinking and a shift from passive to more active learning (Seymour 2004). Summer undergraduate expereinces have been leveraged to address educational disparities across racial, ethnic and gender groups (Ghee et al., 2016). Furthermore, URM students were shown to have higher gains than a comparison group on learning items that included, ability to integrate theory and practice, understanding of science, learning to work independently and becoming part of a learning community (Lopatto 2007). Students who participated in research early in their careers were more likely to persist in STEM fields with positive gains found for first-generation students (Ishiyama, 2001; Seymour, 2004) and students from underrepresented groups (Nagda, 1998). Yet a recent report surrounding Research Experiences for Undergraduate (REU) programs showed that 91% of these programs served juniors and seniors (Langhoff, 2018).

Community colleges are poised to be an essential component in the solution to increase the representation of women and underrepresented minorities in STEM. Forty-four percent of Americans who receive bachelor's degrees in science and engineering attend community college at some point in their education (Tsapogas, 2004). Community colleges provide the most diverse student body in the United States with access to higher education, as they serve people of color, women, non-traditional students, veterans, international students, first-generation students and working parents (Olson and Labov, 2012). While there is a body of literature surrounding student success programs (ex. learning communities, student success courses and supplemental instruction) at community colleges, more work is needed to fully understand the impact of these interventions on community college students (Crisp, 2013). Furthermore, opportunities for community college students to participate in undergraduate research are limited, although there have been recent efforts to build, implement, and sustain undergraduate research experiences at community colleges (Patton, 2020). The program highlighted in this article is a collaboration between community colleges and Kansas State University (KSU), a four-year institution with a program goal to increase confidence and retention of students in STEM fields.

The Research Immersion: Pathways to STEM (RIPS) program is coordinated by the Kansas Louis Stokes Alliance for Minority Participation (KS-LSAMP). KS-LSAMP, funded by the National Science Foundation, aims to increase the quality and quantity of underrepresented students successfully completing baccalaureate degrees in STEM. The program includes specialized activities at critical junctures in a student's academic life cycle such as high school to college; two-year to four-year institutions; and the critical freshman-to-sophomore transition at four-year institutions. The alliance is comprised of two four-year baccalaureate granting institutions and five community colleges throughout the state of Kansas.

The conceptual framework for this project integrates three distinct and complementary theories: retention/integration theory, cumulative advantage theory, and engagement theory. Retaining more students of color at their first college to degree completion is key to improving STEM completion. Research findings provided ample evidence for targeted, programmatic efforts that not only increased baccalaureate attainment but also increased the number of STEM graduates.

Framework 1: Retention theory/integration theory: Theorists (Spady, 1970; Tinto, 1975; Astin, 1993; Tinto, 1997) hypothesized that student degree progress and completion were influenced by social and academic integration within an institution. More recent integration theories also posited other aspects of the institutional environment that play a role in retention of underrepresented students, such as climate and practices fostered by institutional agents (Nora, 2003; Hernandez and Lopez, 2004; Nora et al., 2005), in their study of the "leaking pipeline" for Latino/a college students, reviewed personal, environmental, involvement and socio-cultural factors influencing student persistence in higher education. Researchers in retention theory suggested subcomponents of retention that informed the work of this project: resilience, identity, and academic self-concept.

Academically resilient students were described as students "who sustain high levels of achievement motivation and performance despite the presence of stressful events and conditions that place them at risk of doing poorly in school and ultimately dropping out of school" (Alva, 1991, p. 19). The resilience construct was used by researchers to identify factors that accounted for success; also described as protective factors that moderated the influence of risk factors on outcomes. Factors that impact resilience were support (i.e. family and peer support; teacher feedback), sense of belonging, and cultural loyalty (Gonzalez and Padilla, 1997).

The development of a strong science identity has been shown to improve persistence among science majors (Chang et al., 2011) and to shape students' trajectories within scientific disciplines (Carlone and Johnson, 2007). Carlone and Johnson's (2007) model of science identity included competence, performance, and recognition. Students with strong science identities were those who demonstrated competence in the discipline, possessed the skills to perform scientific practices, and achieved recognition (from themselves and from meaningful others) as a "science person". Thus, given the high attrition rates found in STEM disciplines (Hernandez and Lopez, 2004) practitioners and policymakers needed to identify best practices that promote students' development of a stronger identity with their STEM major. A critical component to students' STEM identity development and socialization into the sciences involved being seen by relevant others as a science person (Carlone and Johnson, 2007). Being mentored, recognized, or validated as competent in science by faculty and peers helped students develop strong, positive STEM identities. Researchers also highlighted several college experiences and contexts that influence science identity development. Hurtado et al. (2009) found that undergraduate research experiences enhanced student interest in becoming a scientist, as students improved their knowledge and understanding of science (Sabatini, 1997) and developed their professional self-confidence (Mabrouk and Peters, 2000; Lopatto, 2003).

Research has shown that higher academic (rather than social) self-concept is evidenced among STEM completers and initial STEM identity played a small but significant role among completers. Sedlacek (1989) reported that a strong academic self-concept was important for URM students; Astin (1982) found that academic self-concept was related to persistence in postsecondary education for students of color. Hernandez and Lopez (2004) suggested that academic advisory staff examine academic self-concept and facilitate its development, including sensitizing faculty and staff to contribute to its development through encouragement, meaningful engagement and constructive critique and feedback.

Framework 2: Engagement theory (e.g. (Kearsley and Shneiderman, 1998)) was based upon the idea that when students were meaningfully involved in their learning through interactive and worthwhile tasks there were multiple benefits to the learner. When students were engaged they considered the activity to be personally meaningful, interest and persistence were promoted, self-efficacy was increased, and optimum academic performance was produced (Kearsley, 1997). Students who were engaged learned at high levels, retained what they learned and transferred their learning to new contexts. Therefore, diverse and engaged participants at all levels (e.g. faculty, advisors, administrators) were an essential element of program design. Researchers concerned about students' disinterest and disengagement in STEM at the postsecondary level, especially in URM students and women, argued for a shift toward student-centered pedagogies that fostered a more supportive environment and connected classroom content to its application in the "real world" (Eagan et al., 2014; Estrada et al., 2016). Connecting content to its application in professional contexts or demonstrating its relevance to students' lives improved the STEM classroom experience (Davis and Finelli, 2007).

Framework 3: The theory of cumulative advantage (e.g. (Allison et al., 1982; Zuckerman, 1988) is especially relevant to this project because it provides a mechanism for understanding inequality across a temporal process (e.g., high school, college, lifetime). The theory posited that a favorable relative position facilitated further relative gains (DiPrete and Eirich, 2006). For example, research on the career trajectories of scientists demonstrated a pattern of growth in maintenance of inequality with respect to productivity, recognition, and performance, as early career success attracted new resources and rewards that promoted continued high levels of achievement (Allison and Stewart, 1974; Zuckerman, 1988). In education, a cumulative advantage process was "capable of magnifying small differences over time and made it difficult for an individual or group that was behind at a point in time in educational development to catch up" (DiPrete and Eirich, 2006, p. 272). Eagan and his colleagues (Eagan et al., 2013) noted that in regard to STEM students' developing science identities, cumulative advantage theory suggested that students who, prior to college, had access to particular resources or experiences (i.e., parent in a STEM career, pre-college research experiences, recognition as highly competent in STEM) that helped develop relatively stronger STEM identities early were more likely to have an even stronger relative STEM identities in the future, especially since they tended to gain greater access to those important resources and activities during college.

Research questions: There are two areas that encompass elements of these three frameworks that have existing quantitative elements instruments: Academic self-concept and STEM identity. This lends itself to two research questions that will be addressed in this manuscript:

1) Does the RIPS Summer Research Program with integrated University experiences increase academic self-concept?
2) Does the RIPS Summer Research Program with integrated University experiences increase STEM interest and STEM identity?

Since this RIPS program is unique in its focus on community college students, these research questions make a new addition to existing literature.

## METHODOLOGY

Program information was advertised at community colleges and a four-year institution. Student eligibility included completion of college-level Algebra and one college-level science course with accompanying lab. As this program was designed as an

**TABLE 1** | Demographic information.

| | N = 53 |
|---|---|
| Gender | |
| Male | 30 (57%) |
| Female | 23 (43%) |
| Race-ethnicity | |
| Black or african american | 3 (6%) |
| Asian or asian american | 4 (7%) |
| Hispanic or latino | 44 (83%) |
| White | 2 (4%) |
| Institutional status | |
| Community college | 41 (77%) |
| Four-year institution | 12 (23%) |
| Parental/guardian education | |
| First-generation | 40 (75%) |
| Continuing education | 13 (25%) |

introduction to undergraduate research, students did not need to have prior research experience. Applications included a personal statement and two letters of recommendation from STEM faculty members.

Selected students were invited to stay in on-campus housing at the four-year institution for the entirety of the eight-week program. Student participants worked in research labs between 30 and 35 h per week. In addition to research-focused work, students were asked to attend a seminar two times per week. This seminar time included supplemental information to enhance students' research experiences, information related to campus life at a four-year institution and time for the cohort to interact socially. The program culminates in students writing a research abstract and presenting a research poster to the KSU community.

Towards the end of the program, retrospective surveys were administered to participants and kept open for a two-week period. Surveys were entered into the online survey system, Qualtrics, and distributed via email. Follow-up emails were sent to encourage survey completion and increased response rates as the survey close date occurred after program participants had returned home from the program. Fifty-three students participated in the program from 2015–2019. Students also participated in semi-structured focus groups. The purpose of the mixed method design was to elaborate and enhance the results from the quantitative surveys (Schoonenboom and Johnson, 2017).

Survey instruments developed by the KSU Office of Educational Innovation and Evaluation (OEIE) for the RIPS program reflected the Dillman Tailored Design Method (Dillman et al., 2014) in regard to the following: 1) item development and selection, 2) use of appropriate scales, 3) layout, and 4) general questionnaire formatting for clarity and utility. The surveys were primarily utilized to assess changes in student participants' STEM interest, STEM identity, sense of belonging, resiliency, and future academic and/or career goals/intentions. Survey items and focus group questions were carefully selected from the works of Lent et al. (1986), Hurtado and Carter (1997), Luzzo et al. (1999), and Eagan et al. (2014). Project activities took place annually and surveys were administered at the conclusion of each activity. The focus group design and analysis utilized the methodology outlined in Krueger and Casey (2009). The design of these instruments for the evaluation of this program was discussed in more detail previously (Grauer et al., 2015).

## RESULTS AND DISCUSSION

Information about the demographics and overall perception of the program experience will further understanding of the results relevant to the research questions. **Table 1** shows the majority of program participants (83%) identified as Hispanic or Latino with a home institution at a community college. Additionally, 75% of students (40 of 53) identified as first-generation as defined by those whose neither parent or guardian earned a four-year degree.

Of the fifty-three students surveyed over a five-year period, forty-four submitted surveys at the completion of the program (response rate of 83%). Participant satisfaction was high, as shown in **Table 2**, and all but two participants felt the program was worth their time. While participants had extremely positive experiences in the program, there is not as strong an indication that the program helped them clarify the field of interest or decide career path that is best for them.

### RQ1: Does a Summer Research Program With Integrated University Experiences Increase Academic Self-Concept?

The results in **Table 3**, **4** demonstrate that the RIPS program increased the participants' academic self-concept. There were mean increases in all items surveyed related to academic self-concept.

The question, "I am able to study and improve in courses that may be hard for me" had three disagrees and seven neutral responses in the before reflection but no negative or neutral responses in the after reflection of the summer program. No other question moved that many negative or neutral responders to positive responders.

Focus groups were also held at the end of each summer session for cohorts 1, 2, and 3 to better illustrate and enhance the qualitative data. The focus group questions are provided in **Table 5**.

The quantitative changes in the responses to the question, "I am able to study and improve in courses that may be hard for me" are further explained by the response to question four in the focus group which is synthesized in **Table 6**. A major theme that arose in the discussion of question four for every cohort was the need for patience/persistence/determination.

Looking directly at student quotes, students tie this patience and persistence to the value of hard work compared to innate ability.

> "It takes patience. You can't say 'I'm not smart enough to be a scientist.'" (Cohort 1)
>
> "Even though you're failing, you can't get something right, you still have to keep at it because all your hard

**TABLE 2 |** Overall program experience $N = 44$.

| Question | Strongly Disagree | Disagree | Neither Agree or Disagree | Agree | Strongly Agree | Mean (SD) |
|---|---|---|---|---|---|---|
| I felt satisfied with the way the RiPS summer program was conducted[a] | 2 | 1 | 2 | 7 | 20 | 4.31 (1.15) |
| The RiPS summer program met my expectations[a] | 2 | 1 | 1 | 10 | 18 | 4.28 (1.11) |
| I found the RiPS summer program to be worth my time and effort[a] | 2 | — | — | 6 | 24 | 4.56 (1.01) |
| The RiPS summer program encouraged me to meet with staff, faculty or others about my STEM interest and education | 2 | — | 1 | 20 | 21 | 4.32 (0.91) |
| The RiPS summer program encouraged me to get involved with activities and organizations related to my STEM interests | 2 | — | 4 | 19 | 19 | 4.20 (0.95) |
| The RiPS summer program faculty and staff provided me with feedback about my academic work | 2 | — | 5 | 17 | 20 | 4.20 (0.98) |
| The RiPS summer program faculty and staff believed in my potential to succeed as a scientist | 2 | 1 | 1 | 14 | 26 | 4.39 (0.99) |
| The RiPS summer program faculty and staff recognized my achievements in STEM education | 2 | 1 | 4 | 17 | 20 | 4.18 (1.02) |
| The RiPS summer program clarified which STEM field I want to study | 2 | 1 | 16 | 12 | 13 | 3.75 (1.06) |
| The RiPS summer program clarified whether graduate school was a good choice for me | 1 | 1 | 11 | 15 | 16 | 4.00 (0.96) |
| The RiPS summer program clarified whether I want to pursue a science research career | 2 | 1 | 8 | 16 | 17 | 4.02 (1.05) |
| The RiPS summer program increased my network of professional STEM contacts | 2 | — | 2 | 13 | 27 | 4.43 (0.95) |

[a]*These questions were not included in the 2019 survey and have an N = 32.*
*Note: The same two respondents almost consistently chose "Strongly disagree".*

**TABLE 3 |** Survey items related to academic self-concept.

| Item | | Strongly Disagree | Disagree | Neither Agree or Disagree | Agree | Strongly Agree | Total | Mean (SD) |
|---|---|---|---|---|---|---|---|---|
| I believe that I can accomplish my goal of graduating at my current institution | Before | — | — | 3 | 24 | 16 | 43 | 4.30 (0.60) |
| | After | — | — | 2 | 9 | 29 | 40 | 4.68 (0.57) |
| I have the capability of achieving success in my education | Before | — | 2 | 3 | 24 | 14 | 43 | 4.16 (0.75) |
| | After | — | — | 1 | 15 | 24 | 40 | 4.58 (0.55) |
| I believe I am able to help other students be successful in their coursework | Before | — | 2 | 10 | 26 | 5 | 43 | 3.79 (0.71) |
| | After | — | — | 4 | 21 | 15 | 40 | 4.28 (0.64) |
| I am able to study and be successful in courses that may be hard for me | Before | — | 3 | 7 | 24 | 9 | 43 | 3.91 (0.81) |
| | After | — | — | — | 24 | 16 | 40 | 4.40 (0.50) |
| I believe I am an important part of my school/institution | Before | 1 | 3 | 12 | 16 | 11 | 43 | 3.77 (1.00) |
| | After | — | 2 | 5 | 13 | 20 | 40 | 4.28 (0.88) |
| I will be successful in a career after I graduate | Before | — | 1 | 9 | 21 | 12 | 43 | 4.02 (0.77) |
| | After | — | — | 4 | 15 | 21 | 40 | 4.43 (0.68) |
| I am confident in my academic knowledge and abilities | Before | 1 | 3 | 8 | 22 | 9 | 43 | 3.81 (0.93) |
| | After | — | 2 | 2 | 19 | 17 | 40 | 4.28 (0.78) |

work, if you just gave up then, then nothing matters" (Cohort 3)

While not part of the original framework guiding this program, elements seen in the student response could be explained through Mindset Theory. Mindset Theory, first described by Carol Dweck, examines the effects on the underlying beliefs about intelligence and how those beliefs impact motivation, responses to challenges, and beliefs about effort (Dweck, 2006). More recently, Dringenberg et al., 2019 have examined "smartness" as an important construct related to but distinct from intelligence. Additionally, some of the changes in participant perception about their ability may also be attributed to the social comparisons that they are able to make during the program, seen in the responses to Question 2 provided in **Table 7**.

"I think this helped me be encouraged even more because I've met people who struggle as much as I do" (Cohort 3)

When there is a lack of task-oriented feedback, individuals will compare themselves to their peers to help make determinations about their performance (Dijkstra et al.,

**TABLE 4 |** Analysis of Survey items related to Academic Self-Concept.

| Item | Before Participating Median | After Participating Median | N Pairs | Wilcoxon Signed-Rank Z |
|---|---|---|---|---|
| I believe that I can accomplish my goal of graduating at my current institution | 4 | 5 | 39 | Z = -3.1; $p$ = 0.002 |
| I have the capability of achieving success in my education | 4 | 5 | 39 | Z = -3.2; $p$ = 0.001 |
| I believe I am able to help other students be successful in their coursework | 4 | 4 | 39 | Z = -3.9; $p$ < 0.001 |
| I am able to study and be successful in courses that may be hard for me | 4 | 4 | 39 | Z = -3.3; $p$ = 0.001 |
| I believe I am an important part of my school/institution | 4 | 4.5 | 39 | Z = -3.3; $p$ = 0.001 |
| I will be successful in a career after I graduate | 4 | 5 | 39 | Z = -3.3; $p$ = 0.001 |
| I am confident in my academic knowledge and abilities | 4 | 4 | 39 | Z = -3.5; $p$ < 0.001 |

**TABLE 5 |** Semi-structured focus group questions.

| | |
|---|---|
| Question 1 | Please tell me a little bit about your summer experiences in the RiPS program? |
| Question 2 | Are you more encouraged or less encouraged about majoring in a STEM program and pursuing a career in science, math of engineering? Explain |
| Question 3 | In what ways did being a part of a COHORT strengthen or deepen your research experience? |
| Question 4 | What would you say are the key elements of “being a good scientist”? What does a good scientist “look like” to you? |
| Question 5 | What have you found to be the hardest part of studying STEM? The easiest? The most exciting? |

**TABLE 6 |** Themes mentioned in the focus group discussion in response to Question 4.

**Question 4: What would you say are the key elements of “being a good scientist”? What does a good scientist “look like” to you?**

| Theme | Number of Times Mentioned | | | |
|---|---|---|---|---|
| | Cohort 1 | Cohort 2 | Cohort 3 | Total |
| Patience/persistence/determination | 6 | 1 | 2 | 9 |
| Interest/curiosity/passion for topic | 4 | 1 | | 5 |
| Problem-solving | 2 | | 1 | 3 |
| Receptive of failure/mistakes | | 1 | 2 | 3 |
| Effective communication/collaboration | | 1 | 2 | 3 |
| Careful (adheres to lab safety protocols) | | 2 | | 2 |
| Time management | 1 | | | 1 |
| Positive attitude | 1 | | | 1 |
| Realizing your potential | 1 | | | 1 |
| Calm under pressure | | 1 | | 1 |
| Detail-oriented | | 1 | | 1 |
| Ethical/honest | | 1 | | 1 |
| Responsible | | 1 | | 1 |
| Be yourself | | 1 | | 1 |
| Scientists can be from any racial/cultural background | | 1 | | 1 |
| Professional, but are also human beings | | | 1 | 1 |

2008). In academic settings, this can primarily be through grades but students may also look for a wide-range of behaviors to better understand and make judgements about their performance such as how long others studied or how quickly someone finished an exam (Dijkstra et al., 2008; Garcia et al., 2013). In traditional academic settings, the cues that students receive are often ambiguous and students may create a false sense of their ability (positive or negative). Secules et al., 2018 have looked at “Engineering Ability” as a culturally constructed idea that can lead students to make judgements about not being “cut out” for engineering. However, in an immersive experience such as the RIPS program, students can’t make as many assumptions about student behavior; they see it all. They also receive significant task-oriented feedback and support compared to the traditional academic setting, which allows them to create a positive avenue to view effort and challenges as a path towards mastery.

Sense of belonging is increased along with self-efficacy. The question, “I believe I am an important part of my school/institution,” had the largest mean increase in the retrospective survey. This is very interesting as the students all came from several different institutions.

Some of the themes that arose in question 1 of the focus group were that either the mentor/research team cared about the

**TABLE 7 |** Themes mentioned in the focus group discussion in response to Question 2.

| Question 2: Are you more encouraged or less encouraged about majoring in a STEM program and pursuing a career in science, math of engineering? Explain | | | | |
|---|---|---|---|---|
| **Theme** | **Number of Times Mentioned** | | | |
| | **Cohort 1** | **Cohort 2** | **Cohort 3** | **Total** |
| More encouraged | 8 | 1 | 7 | 16 |
| Neither more nor less encouraged | | | 2 | 2 |
| **Explanation** | | | | |
| Better understanding of future direction | 5 | | | 5 |
| Positive experience with mentor and/or lab mates | | | 5 | 5 |
| Helped decide on my major | 4 | | | 4 |
| Being exposed to what others do and experience in the field/major is encouraging | | | 4 | 4 |
| Hands-on experience | 3 | | 2 | 5 |
| Feel comfortable/encouraged about continuing education | 3 | | | 3 |
| Learned value of good communication skills | | | 3 | 3 |
| Learned independent study skills | | | 3 | 3 |
| Interest in non-research lab-based career | | 2 | | 2 |
| Still unsure of direction in terms of major/career | | 2 | | 2 |
| May change major | | 2 | | 2 |
| Questioned/reconsidered major | | | 2 | 2 |
| Mentors were unavailable for a period(s) of time | | | 2 | 2 |
| More knowledgeable | 1 | | | 1 |
| Overwhelmed with the variety of major/career path options | | 1 | | 1 |
| Pressure to choose major quickly due to personal reasons or family obligations | | 1 | | 1 |
| Enjoys service-oriented side of STEM | | | 1 | 1 |
| Professional networking | | | 1 | 1 |
| No graduate student/other staff member support | | | 1 | 1 |
| Graduate student support helped | | | 1 | 1 |
| Learned independent research skills | | | 1 | 1 |

student or that the students had positive experience with and received support from their peers. The support from the mentor/research team was primarily discussed by Cohort 1, as shown in **Table 8**.

> "They cared a lot about what we had to say and if we didn't understand they explained it until we got it." (Cohort 1)

These findings can also be related back to Framework 2: Engagement theory. The creation of a supportive environment through mentors and peers increases not self-efficacy but drove interest and performance.

The support coming from peers was discussed across cohorts, as seen in **Table 9**. Connecting as a cohort and building academic skills may also be important because it builds on the confidence and accomplishment gained by a research experience. Which maps to both Framework 2: Engagement theory and Framework 3: Cumulative advantage theory. Positive research experiences may be more important than a perfect research interest match.

The survey results (**Table 3**) for academic self-concept showed that all items increased in the reflective surveys. Furthermore, in **Table 4**, it is shown that all items showed a statistically significant increase (most items $p$=<0.001) when reflecting on before and after participation.

Of particular note were large average increases for "I am able to study and be successful in courses that may be hard for me" and "I believe I am an important part of my school/institution." Focus group responses to Question 1–4 elicited responses related to academic self-concept. The importance of patience and persistence was noted across the cohorts and helps elucidate why students increased their rating of "I am able to study and be successful in courses that may be hard for me." This is in line with Framework 1: Retention theory/integration theory and further demonstrates the relationship between resilience, identity, and academic self-concept.

## RQ 2: Does a Summer Research Program With Integrated University Experiences Increase STEM Interest and STEM Identity?

The results from the surveys, shown in **Tables 10**, **11**, demonstrated a significant increase in STEM identity.

The STEM identity increase is nuanced. While there is an increase in the mean for the question, "I see myself as a science or math person," **Table 11** shows that this increase is not statistically significant ($p$ = 0.073). All other items in the STEM identity section of the survey had statistically significant increases.

There is a barrier between being a person that tests well in math or science and actually seeing yourself as someone who can become accomplished and succeed in STEM. Being able to communicate with others about interests in STEM and knowledge acquired is also discussed by students in Cohort 2 and 3 in response to Question 4: What would you say are the key elements of "being a good scientist"? What does a good scientist "look like" to you? (**Table 6**).

**TABLE 8 |** Themes mentioned in the focus group discussion in response to Question 1.

**Question 1: Please tell me a little bit about your summer experiences in the RiPS program?**

| Theme | Number of Times Mentioned | | | |
|---|---|---|---|---|
| | Cohort 1 | Cohort 2 | Cohort 3 | Total |
| Gained a deeper understanding of field/discipline and those working in the field | 6 | | | 6 |
| Mentor/research team cared about me/helped me | 5 | | | 5 |
| Valuable career exploration | 2 | | 3 | 5 |
| Provided hands on experience | 4 | | | 4 |
| Networked/met new people | 3 | | | 3 |
| Personal growth/recognizing one's potential | 1 | | 2 | 3 |
| Valuable team experience | 2 | | | 2 |
| Unique internship experience | 2 | | | 2 |
| Seminars could be improved (complaints include: seminars are too long; seminars conflicted with lab time; some seminar topics weren't as relevant to undergrads) | | 2 | | 2 |
| Experienced challenges with the dorm (beds, smell, food, weak wi-fi signal) | | 2 | | 2 |
| Positive social experience/meeting new people/friendships | | 2 | | 2 |
| Mentors were unavailable for a period(s) of time | | 2 | | 2 |
| Hands-on experience (including management experience) | | 2 | | 2 |
| Was not assigned to mentor in STEM field of interest | | 2 | | 2 |
| No graduate student/other staff member support | | 2 | | 2 |
| Explore majors | | | 2 | 2 |
| Participating lead to a job opportunity | 1 | | | 1 |
| Campus/library tours were helpful | | 1 | | 1 |
| Did not find all seminar topics to be immediately useful | | 1 | | 1 |
| Positive experience with mentor | | 1 | | 1 |
| Too much lab work towards end of program (took away from poster presentation) | | 1 | | 1 |
| Multiple mentors/experiences | | 1 | | 1 |
| Would like to have received preparatory/orientation like materials before starting RiPS (i.e. learn where they will be placed; preparatory reading list about research topic) | | 1 | | 1 |
| Graduate student support helped | | 1 | | 1 |
| Productive way to spend the summer | | | 1 | 1 |
| Sense of accomplishment | | | 1 | 1 |

**TABLE 9 |** Themes mentioned in the focus group discussion in response to Question 3.

**Question 3:In what ways did being a part of a COHORT strengthen or deepen your research experience?**

| Theme | Number of Times Mentioned | | | |
|---|---|---|---|---|
| | Cohort 1 | Cohort 2 | Cohort 3 | Total |
| Members of cohort provided support | 2 | 1 | 6 | 9 |
| Being with others of a similar cultural background increased comfort level when on campus | | 2 | | 2 |
| Did not spend as much time together as a whole group (due to program scheduling) | | | 2 | 2 |
| Team motivated me | 1 | | | 1 |
| Sense of belonging | 1 | | | 1 |
| Experience may have been different without cohort members | 1 | | | 1 |
| Positive experience | | 1 | | 1 |
| Shared information about the different fields STEM fields | | 1 | | 1 |
| Coming from diverse backgrounds led to a diverse experience | | | 1 | 1 |

"You could be the most brilliant person in the world and have discovered something really cool, but if you can't explain it to anyone, no one knows what the hell you just did or why it matters, what good does it do anyone?" (Cohort 3)

> "The importance of not only being able to get the results, but being able to explain them in a way that you can teach it to other people and be able to spread it to them and let them see the importance of the information that you gathered." (Cohort 3)

Cohort 1 did not mention the need for more effective communication but as previously mentioned all cohorts discussed the needs for patience and persistence. Cohort 1 also discussed the need for interest and curiosity.

> "The person has to be curious and they should be able to dig deeper into their subject." (Cohort 1)
> "You also have to have an interest for what you're doing. You have to have that passion for learning." (Cohort 1)

**TABLE 10 |** Items related to STEM identity.

| Item | | Strongly Disagree | Disagree | Neither Agree or Disagree | Agree | Strongly Agree | Total | Mean (SD) |
|---|---|---|---|---|---|---|---|---|
| I see myself as a science or math person | Before | 1 | 1 | 2 | 22 | 17 | 43 | 4.23 (0.84) |
| | After | — | 1 | 1 | 15 | 24 | 41 | 4.51 (0.68) |
| I Have a lot of pride in my accomplishments in science/math | Before | 1 | 2 | 13 | 17 | 10 | 43 | 3.77 (0.95) |
| | After | — | — | 5 | 15 | 21 | 41 | 4.39 (0.70) |
| When it comes to scientific Knowledge and understanding I can compete at the highest levels | Before | 2 | 6 | 15 | 17 | 3 | 43 | 3.30 (0.96) |
| | After | — | 2 | 8 | 18 | 12 | 40 | 4.00 (0.85) |
| I enjoy talking about science and/or math with others | Before | 1 | 1 | 5 | 22 | 14 | 43 | 4.09 (0.87) |
| | After | — | — | 2 | 16 | 23 | 41 | 4.51 (0.60) |
| I am active in organizations or groups related to science, math, or engineering | Before | — | 6 | 7 | 23 | 7 | 43 | 3.72 (0.91) |
| | After | — | 3 | 3 | 18 | 17 | | 4.20 (0.87) |
| I am interested in reading websites, magazines or books about scientific issues | Before | 3 | 5 | 13 | 17 | 5 | 43 | 3.37 (1.07) |
| | After | — | 1 | 5 | 21 | 14 | 41 | 4.17 (0.74) |
| I am interested in helping others use science | Before | — | 7 | 12 | 23 | 7 | 43 | 3.84 (0.72) |
| | After | — | 1 | 3 | 16 | 21 | 41 | 4.39 (0.74) |
| I am interested in the way science and engineering help people | Before | 2 | 2 | 2 | 23 | 14 | 43 | 4.05 (1.00) |
| | After | 1 | 1 | — | 12 | 27 | 41 | 4.54 (0.84) |

**TABLE 11 |** Analysis of responses to items related to STEM identity.

| | Before Participating Median | After participating Median | N Pairs | Wilcoxon Signed-Rank Z |
|---|---|---|---|---|
| I see myself as a science or math person | 4 | 5 | 40 | Z = −1.8; $p$ = 0.073 |
| I Have a lot of pride in my accomplishments in science/math | 4 | 5 | 40 | Z = −3.7; $p$ < 0.001 |
| When it comes to scientific Knowledge and understanding I can compete at the highest levels | 3 | 4 | 39 | Z = −4.2; $p$ < 0.001 |
| I enjoy talking about science and/or math with others | 4 | 5 | 40 | Z = −3.6; $p$ < 0.001 |
| I am active in organizations or groups related to science, math, or engineering | 4 | 4 | 40 | Z = −3.8; $p$ < 0.001 |
| I am interested in reading websites, magazines or books about scientific issues | 4 | 4 | 40 | Z = −3.9; $p$ < 0.001 |
| I am interested in helping others use science | 4 | 5 | 40 | Z = −4.0; $p$ < 0.001 |
| I am interested in the way science and engineering help people | 4 | 5 | 40 | Z = −3.6; $p$ < 0.001 |

The interest in STEM was already there, however students needed to understand the importance of scientific communication and have confidence in their ability to be part of the process to strongly agree with statements such as, "I am interested in reading websites, magazines or books about scientific issues", "I am interested in helping others use science", and "I enjoy talking about science and/or math with others." In response to question 1: "Please tell me a little bit about your summer experiences in the RiPS program?" in the focus groups students also discussed the value of gaining a deeper understanding of the field as well as hands-on experience.

> "So seeing everything how it actually works and what it all actually means to begin with and how deep it actually goes to understand everything in my field I'm trying to go into." (Cohort 1)

These results can also be explained through our guiding framework of cumulative advantage theory. Students needed to gain academic, communication, and research skills to fully recognize and express their interests. The majority of students expressed feeling more encourage after participating in the program. The explanation for their response to Question 2: "Are you more encouraged or less encouraged about majoring in a STEM program and pursuing a career in science, math of engineering? Explain," included understanding their future direction, building their skills, getting hands-on experience, and positive experiences with their mentor and peers, as shown in **Table 7**.

> "When you are able to experience the forefront of research in an area of study, you can understand where you maybe best fit within your study" (Cohort 1)
>
> "I feel more comfortable now so I do plan on coming here during the fall. So I think it was very helpful for deciding whether or not to major in biochemistry." (Cohort 1)
>
> "I worked a lot with my advisor. That was really great. He was really good at what he does." (Cohort 3)

Results from this work are in alignment with Graham's work surrounding persistence (Graham, 2013) and Retention theory. His work emphasized the importance of both learning and professional identification as key to persistence in STEM. Responses to question 5, shown in **Table 12**, also explain the

**TABLE 12 |** Themes mentioned in the focus group discussion in response to Question 5.

| Question 5: What have you found to be the hardest part of studying STEM? | | | | |
|---|---|---|---|---|
| **Theme** | **Number of Times Mentioned** | | | |
| | **Cohort 1** | **Cohort 2** | **Cohort 3** | **Total** |
| Lack of background knowledge | 5 | | | 5 |
| Complexity of STEM/STEM content | | 3 | 1 | 4 |
| Lab experiments (e.g., minute details, failed results) | | 3 | | 3 |
| Lack of research/lab experience | 2 | | | 2 |
| Scientific reasoning | 2 | | | 2 |
| Self-motivation | 2 | | | 2 |
| Steep learning curve from high school to community college to the university | | | 2 | 2 |
| Time management | | | 2 | 2 |
| Choosing a STEM major/career | | 1 | | 1 |
| Learning critical thinking skills | | | 1 | 1 |
| Many different ways to do things | | | 1 | 1 |
| Not being #1/competitive | | | 1 | 1 |
| Shadowing mentor rather than assisting (not being able to engage in experiential process) | 1 | | | 1 |
| Understanding how the experience is relevant to the future | | 1 | | 1 |
| **The easiest part?** | | | | |
| Support from peers and faculty/staff | 6 | | | 6 |
| Collegial learning and working environment | 4 | | | 4 |
| Program was well-organized and provided necessities (e.g., room and board, food, monetary support) | 3 | | | 3 |
| Positive social environment | 2 | | | 2 |
| Understanding/when it all comes together in your mind | 2 | | | 2 |
| Following the plan you have created | 1 | | | 1 |
| Getting into a routine after getting used to the program | | | 1 | 1 |
| Learning overlaps between projects (synergy) | 1 | | | 1 |
| Attending seminars | | | 1 | 1 |
| Looking forward to the future | | | 1 | 1 |
| **The most exciting part?** | | | | |
| Lab work (e.g., knowledge gains, groundbreaking discoveries, state of the art lab equipment) | 2 | 4 | | 6 |
| Sense of accomplishment (poster presentation) | 3 | | 3 | 6 |
| New STEM knowledge/skills | 3 | 2 | | 5 |
| Professional networking | | 5 | | 5 |
| Exploring future study/career options or paths | 3 | | | 3 |
| Preview of the future (whether it is career/major prospects or moving to K-State) | | | 3 | 3 |
| Product testing/development | | 2 | | 2 |
| Enjoyable seminars | 1 | | | 1 |
| Experiencing campus life | | | 1 | 1 |
| Moment it all came together/understanding | 1 | | | 1 |
| **Other** | | | | |
| Lab schedule was not flexible enough | | | 1 | 1 |
| Pleasantly surprised by schedule flexibility (general) | | | 1 | 1 |
| Please continue program with other students | 1 | | | 1 |

increase in the sense of pride and accomplishment. Students were excited about getting to be a part of groundbreaking discoveries and learning new skills.

> "I think one of the most exciting things is when you're researching something like they kind of said is like groundbreaking, something that nobody's really knows about." (Cohort 2)

All items in **Table 10** showed an increase in STEM identity. In the response to questions 2, 4, and 5 during the focus groups students also discussed themes related to STEM identity. It is interesting that Question 4: "What would you say are the key elements of "being a good scientist"? What does a good scientist "look like" to you?" elicited rich responses related to both academic self-concept and STEM identity.

## Program Impact

Since the beginning of the program, 5 years ago, 39/41 (95%) of community college participants have transferred to a four-year institution. This is exceptional as a recent report from the National Student Clearinghouse Research Center noted that from a 2010 cohort of 852,439 students, 31.5% of students transferred to a four-year institution within six-years (Shapiro, 2017).

## LESSONS LEARNED, RECOMMENDATIONS AND FUTURE WORK

Coordination of this program over the past 5 years has resulted in several lessons that are noted below.

### Research Supplementation

Being mindful that we were working with novice undergraduate research students from underrepresented groups, we decided to create additional support systems to aid in student success. Program coordinators and participants met twice per week to discuss topics that supplemented individual student experiences. Content for the weekly seminar was developed using the Entering Research curriculum (Branchaw, 2020). This curriculum helps novice undergraduate students navigate the process of conducting research, develop mentoring relationships and helps to create a learning community among program participants (Balster, 2010). Seminars were designed to foster student engagement and time was intentionally set aside for cohort building.

### Cohort Activities

Throughout the program, various social activities were scheduled to help students develop relationships among themselves in an informal setting. Activities included bowling, playing team sports together, group game nights or field trips to local attractions (ex. zoo, botanical garden etc.). Since the majority of program participants were first-generation and often from underrepresented backgrounds, we wanted to create informal spaces for them to be themselves and talk with each other. Additionally, some of these activities provided an opportunity for students to leave campus and explore the town. This was more relevant to our community college students as they were thinking of potentially transferring to a four-year institution.

### Collaborations With Other Summer Programs

Building relationships with other campus groups can aid in the success of an individual program. During a typical summer, there are several groups on campus that coordinate undergraduate summer research experiences. Coordinators from each group are part of a campus-wide Undergraduate Research Experience Consortium. The group meets once or twice prior to the start of summer programs to learn about program updates and strategically plan group activities. Signature events that all summer undergraduate students were invited to include a BBQ or ice cream social and a field trip to a local federally funded research site. The goal of the group events was to showcase the various undergraduate programs on campus and to have students engage across programs.

### Program Staff

An enthusiastic coordinator who cares about program participants paired with good staff will ensure that students make meaningful and positive connections during their time in the program.

Specific details related to the above program were changed and/or slightly modified each year based on the cohort, availability and engagement by campus partners.

### Recommendations and Future Work

#### Enhanced Training Opportunities

Student participants spend most of their time in their research lab interacting with faculty mentors, graduate students and/or post docs. The quality of the interactions matters. Providing training to faculty and/or graduate students involved in the program would be helpful. Barnet's work indicated that faculty validation of student significantly predicted intent to persist (Barnett, 2010). Additionally, Langhoff noted that encouraging graduate students who interact with program participants to share their academic journey and challenges may help improve the quality of summer research programs for community college students (Langhoff, 2018). Future programming will include more in-depth training for research mentors. Potential training materials may include portions of the Entering Mentoring curriculum (Pfund et al., 2015).

#### Additional Program Components

In addition to providing information about the research process and opportunities for social interaction, additional student development opportunities can be offered. These may include information about networking followed by specific networking events. Additionally, early career students such as our community college participants may benefit from resume building workshops and opportunities to explore career interests (Crisp, 2013).

In future work, looking at the cultural construction of "smartness" and ability are relatively new areas of research and topics that can be explored with future cohorts. Additionally, more analysis of available qualitative data could be used for assessing the impact of other elements in the framework that guided the development of this program. For example, while engagement theory is related to both identity and academic self-concept, the quantitative data and preliminary analysis of the qualitative data does not paint a complete picture of which tasks were found meaningful and worthwhile. Coding and categorization of qualitative data may be able to elucidate specific recommendations on the more effective University activities.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board of Kansas State University. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

BK, BM, and LT contributed to the research design. BK contributed to the data collection. AB, BK, and BM contributed to the data analysis. All authors contributed to the discussion and writing of the manuscript.

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# Cultivating Graduate STEM Pathways: How Alliance-Based STEM Enrichment Programs Broker Opportunity for Students of Color

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To understand how higher education institutions *broker* graduate opportunities for Students of Color (SOCs) in STEM, we employ a single case study of a Louis Stokes Alliance for Minority Participation (LSAMP) alliance. Drawing primarily from student interviews and informed by Small's (2006) organizational brokerage theory, our findings illuminate how 1) alliance-based STEM enrichment programs (SEPs) bridge social capital *via* interorganizational networks and 2) how SEP instability creates barriers to building the trust that is central to the brokerage process. We conclude with recommendations for future research and practice.

**Keywords: social capital, educational enrichment programs, graduate education, students of color, STEM—science technology engineering mathematics**



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## INTRODUCTION

Though Communities of Color (i.e., Blacks/African Americans, Hispanics/Latina/o/x, Native Americans) comprise approximately 33% of the U.S. population (U.S. Census Bureau, 2019), they only made up 12% of the graduate student population in STEM in 2019 (National Science Foundation, National Center for Science and Engineering Statistics, 2019). While a number of factors influence this disparity in the number of Students of Color (SOCs) in graduate STEM programs relative to their representation in the United States, research shows that students who have extensive social networks are more likely to attend graduate school (Martin, 2009). Still, we know very little about how SOCs acquire and leverage their social capital to access graduate education. Lin (1999) defines social capital as the "resources embedded in a social structure which are accessed and/or mobilized in purposive actions" (*p.* 35). Central to this definition are three elements that facilitate social reproduction: *accessibility, embeddedness,* and *use*. Social capital posits that an individual has *access* to resources (e.g., information, influence, social credentials) that are *embedded* in their social network and relationships. The ability to mobilize social capital to garner other forms of capital (e.g., economic, cultural, human) is constrained by the size and quality of the social networks available to the individual. While much of the existing literature illuminates the importance of social capital in students' transitions from high school to college (Perna and Titus, 2005; Pérez and McDonough, 2008; Rios-Aguilar and Deil-Amen, 2012), very little attention is given to post-graduate transitions. Additionally, much of the existing research on social capital and graduate education focuses on students in graduate school (Ovink and Veazey, 2011; Espino, 2014), not those seeking to access graduate school.

For students transitioning from college to graduate study, social capital may include having undergraduate research experiences, recommendations (preferably those written by faculty members), and pedigree (Posselt, 2016). These are sources of capital that SOCs, who have been historically underserved in higher education, may not have equal access to due to a lack of opportunity and limited resources. For example, McCoy et al. (2017) uncovered that SOCs have disparate experiences with faculty across institutional contexts. At predominantly White institutions (PWIs), SOCs may encounter challenges with identifying and accessing supportive mentors compared to their counterparts at historically Black colleges and universities (HBCUs) (McCoy et al., 2017). Consequently, SOCs may have to utilize other institutional agents to attain the support necessary to realize their graduate school goals. STEM enrichment programs (SEPs) that aim to broaden minority participation in STEM have served a critical role in addressing this need.

Research shows that SEPs have been instrumental in supporting SOCs to attain the social capital necessary to access graduate education. Lane's (2015) study of a Louis Stokes Alliance for Minority Participation (LSAMP) program uncovered that the connections students made and the opportunities afforded to them in SEPs influenced their graduate school aspirations. Research on the Meyerhoff Scholars program at the University of Maryland, Baltimore County found that SOCs who participated in their SEP were nearly five times more likely to attend graduate school and complete a Ph.D. in STEM (Maton et al., 2016). Their multi-pronged services and family-like atmosphere are some of the program features that facilitated critical social networks for participants (Maton et al., 2016). Access to undergraduate research experiences, supportive faculty, and relationships with peers with similar interests, provided through SEPs, are some of the driving forces extending SOCs' pathways toward graduate education (Lane, 2015; Lane, 2016).

Despite the importance of SEPs for promoting interest in graduate education, we still know little about *how* they broker social capital for SOCs in STEM. Thus, the purpose of this study was to understand how an alliance-based STEM enrichment program brokers social capital that facilitates entry into graduate education for SOCs. This study contributes to an emerging strand of research that offers an organizational perspective on social capital development and use. Further, this study offers important insights into increasing the participation and success of SOCs in STEM graduate education programs and careers.

## LITERATURE REVIEW

Considering that SOCs are underrepresented in STEM graduate education, scholars have attempted to understand factors that support graduate enrollment. This theme comprises the first part of this literature review. Then, we review relevant literature on how educational opportunity is brokered by higher education. More specifically, we explore who brokers social capital, what resources are brokered and how, and to what end.

### Graduate Pathways for Science Technology Engineering Mathematics Students of Color

While Black and Latina/o/x STEM students are more likely to aspire to obtain graduate or professional degrees than White students, they are less likely to enroll in graduate and professional education (Eagan et al., 2013). Several scholars have examined the factors that thwart graduate pathways (Malcom and Dowd, 2012; McCoy et al., 2017). Malcom and Dowd (2012) studied the role of undergraduate debt in graduate school enrollment for STEM students. They found that both typical and heavy debt borrowing can hinder graduate enrollment for all STEM students; however, for Latina/o/x students, there was a negative effect of "heavy borrowing" on graduate school enrollment. African American students were the most likely to be heavy borrowers; yet, there was no significant effect on their graduate enrollment. Another factor inhibiting graduate participation is how SOCs perceive the STEM environment (McCoy et al., 2017; Castellanos, 2018). For example, when Latinas in STEM perceived the classroom environment as hostile, they were less inclined to pursue a STEM career or graduate education (Casetellanos, 2018). Additionally, for SOCs in STEM, faculty and institutional contexts could play a role in whether students felt encouraged or "weeded out" of STEM (McCoy et al., 2017). At a PWI, SOCs felt that faculty were gatekeepers to resources such as internships and research opportunities that would promote STEM careers and educational pathways. In comparison, students at an HBCU found that faculty created opportunities for them and provided assistance with career guidance or graduate school preparation.

In studying factors that promote SOCs' decisions to pursue a graduate STEM degree, scholars have found that participating in undergraduate research has a strong influence on igniting and sustaining student's aspirations to pursue a graduate or professional degree in STEM (Strayhorn, 2010; Eagan et al., 2013; Russell et al., 2018). STEM students who participated in undergraduate research reported stronger faculty support than students who did not have similar opportunities (Eagan et al., 2013). Moreover, students who had meaningful research experiences (e.g., collected data, analyzed data) had higher levels of graduate school aspirations compared to students who were less involved in the research process (Strayhorn, 2010). Other factors that facilitate graduate enrollment are scholarships and graduate preparatory programs (Myers and Pavel, 2011; MacPhee et al., 2013). A longitudinal study of the Gates Millennium Scholarship Program, a scholarship program for underrepresented minorities that provides funding for students pursuing STEM graduate degrees, found that scholarship recipients were 41% more likely to enroll in a graduate program and 61% more likely to be enrolled in a STEM graduate program than non-program participants (Myers and Pavel, 2011). Similarly, MacPhee et al. (2013) examined STEM students in a McNair Scholars Program, a U.S. Department of Education Program aimed at preparing underrepresented minorities for doctoral studies. This study found that participation in the McNair Scholars Program increased students' self-efficacy and academic performance, which predicted a greater likelihood of applying to graduate or professional school.

## Social Capital and Students of Color in Higher Education

Researchers have found that social capital is often brokered through individuals and educational enrichment programs within higher education. Institutional agents—individuals who occupy high-status positions in an institution (Stanton-Salazar, 2011)—serve as "bridges" (Museus and Neville, 2012) that broker important social capital for students within higher education. Faculty and staff have been found to act as bridges' that connect students to resources within their social networks (Deil-Amen, 2011; Museus and Neville, 2012; Dika and Martin, 2018). For example, Deil-Amen (2011) found that faculty were key in brokering social capital and academic integration for Latina/o/x engineering students. Hurtado et al. (2008) found that STEM students who developed relationships with faculty were more likely to participate in undergraduate research. Peers were also important brokers of social capital (Hurtado et al., 2008; Rincón et al., 2020). For Black students specifically, advice from upper-class students predicted research participation. In addition to individuals, educational enrichment programs have also been found to broker social capital for SOCs (Stolle-McAllister, 2011; Winkle-Wagner and McCoy, 2016; Lane and Id-Deen, 2020), specifically STEM bridge programs (Ovink and Veazey, 2011; Stolle-McAllister, 2011; Lane and Id-Deen, 2020). Graduate school preparatory programs also increased social capital by cultivating student-faculty interactions and creating a network of peer support (Winkle-Wagner and McCoy, 2016).

Institutional agents and educational enrichment programs broker important educational resources that expand educational opportunities for SOCs. Educators (i.e., professors, college personnel, K-12 teachers) act as bridges to internships, research experiences, graduate school opportunities, and scholarships (Dika and Martin, 2018). Martin et al. (2013) found that Latinas in engineering utilized institutional services such as advising and support programs that provided them with crucial information to progress in their major. Additionally, a STEM bridge program brokered peer relationships that led to family-like bonds and social capital for Black college women and high school girls that supported their career aspirations (Lane and Id-Deen, 2020). Similarly, a biology bridge program provided educational services and physical spaces that increased social capital by fostering connections that were instrumental for getting into graduate school or a post-college job (Ovink and Veazey, 2011).

In addition to the types of resources brokered, faculty, and administrators utilized different methods to broker resources for students. Deil-Amen (2011) found that faculty brokered resources such as academic integration and information related to scholarships, academics, and major-related information both in and outside of class. Faculty and upper-level administrators also brokered resources by applying for large grants to create programming or services for SOCs that enhanced their social capital (Garcia and Ramirez, 2018). Furthermore, institutional structures can also have a role in brokering social capital. For example, Beattie and Thiele (2016) found that smaller class sizes facilitate the brokering of social capital by increasing student interaction with faculty and peers. Regardless of the method, interpersonal trust was key for whether students utilized the resources provided by institutional agents (Torres et al., 2006; Museus and Neville, 2012; Ream et al., 2014). Torres et al. (2006) found that Latina/o/x students do not automatically trust authority figures. For many students, shared experiences allowed them to pursue and develop trusting relationships with institutional agents that then allowed them to access important social capital (Museus and Neville, 2012).

Accessing social capital embedded within social networks provides multiple educational benefits for SOCs (Rios-Aguilar and Deil-Amen, 2012; Tovar, 2015; Schwartz et al., 2018). While research has primarily focused on how accumulating social capital supports students' transitions from high school to college (Perna and Titus, 2005; Pérez and McDonough, 2008; Rios-Aguilar and Deil-Amen, 2012), researchers also found that acquiring social capital supports college student outcomes. For example, social capital has been found to impact student GPAs and STEM persistence (Ovink and Veazey, 2011; Tovar, 2015; Schwartz et al., 2018). Resources related to social capital such as meeting an instructor outside of class and participating in a college support program were found to increase Latina/o/x community college students' GPAs and intentions to persist to degree completion (Tovar, 2015). Additionally, McCallen and Johnson (2020) surveyed first-generation college students and measured social capital through their quality of interactions with campus actors (i.e., students, academic advisors, faculty, student services, and administrative staff) and found that greater frequency of faculty interaction and higher numbers of sources of social capital were positively correlated with GPA.

In summary, much attention has been paid to how institutional agents (individuals) act as bridges to important sources of social capital by broadening students' networks and resources embedded within these networks that help students navigate postsecondary institutions (Stanton-Salazar, 2011; Museus and Neville, 2012). Increasingly, researchers are also capturing the important role of educational enrichment programs in extending students' social capital (Stolle-McAllister, 2011; Winkle-Wagner and McCoy, 2016; Lane and Id-Deen, 2020). However, much of this research is focused on individual programs (Stolle-McAllister, 2011; Winkle-Wagner and McCoy, 2016; Lane and Id-Deen, 2020) and the types of social capital garnered through participation in STEM enrichment programs (Ovink and Veazey, 2011; Lane and Id-Deen, 2020) without attending to how higher education institutions, *via* SEPS, tie students to other institutions and partners through interorganizational networks or how this social capital supports graduate school aspirations. To this end, this study extends the literature in two important ways: 1) it explores the process of brokering graduate school-related resources through alliance-based STEM enrichment programs that aim to broaden participation in STEM as well as the forms of resources brokered; and 2) it helps us better understand how social capital facilitates the college to graduate school transition. It does this by exploring two interrelated research questions: *What graduate school-related resources are brokered by alliance-based STEM Enrichment Programs? How do alliance-based STEM Enrichment Programs broker graduate opportunities?*

## CONCEPTUAL FRAMEWORK

For this study, we draw on Lin's (1999) network theory of social capital. In the context of graduate education, social capital can facilitate access to graduate school knowledge, goods, and services that can be exchanged for graduate admissions and enrollment (human capital). Accordingly, one could invest in expanding their networks to garner greater and "higher" quality resources not currently available in existing networks. Extending the example above, an individual could participate in a webinar to learn about (and potentially from) others who have applied to and attended graduate school to increase one's chances of graduate school admission.

Indeed, much of the social capital literature has focused on this very phenomenon of how individuals develop social ties—relationships between individuals—that bridge entry into new networks and assumedly provide access to better resources (Lin, 1999). Small (2006) extends this concept of bridging capital through social ties to the study of individual-organizational ties. That is, how organizations themselves broker resources to individuals by providing access to resources embedded within interorganizational networks. To theorize organizational resource brokerage, Small (2006) studied how childcare centers function as resource brokers for low-income parents. By connecting parents to nonprofit and government agencies, childcare centers *transferred* information, services, and goods embedded within their interorganizational networks to parents utilizing childcare services. According to Small (2006), interorganizational brokerage was dually facilitated by the degree to which a resource was *actively* and *formally* brokered. As an example of both formal and active resource brokering, childcare center staff offered referral services to connect parents with goods and services provided through partner organizations. Importantly, Small (2006) argues that the effectiveness with which resource brokerage occurs is shaped by organizational efficiencies; that is, the extent to which a resource is formalized within an organization (stability), the organization's ability to persist amidst external pressures (resilience), and its ability to build trusting relationships to enable the brokering of sensitive resources (capacity).

Extending Small's (2006) organizational brokerage theory to education, Duncheon and Relles (2019) found this framework useful for understanding how educational institutions become important resource brokers for college-bound, first-generation youth at an urban high school. As such, we apply Small's (2006) organizational brokerage theory to the study of higher education institutions that are members of an alliance within the Louis Stokes Alliance for Minority Participation to understand how interorganizational networks, in this case those facilitated through an alliance-based STEM enrichment program, transmit capital to individuals, in this case, SOCs in STEM.

## METHODOLOGY

To understand how social capital is embedded and transmitted to individuals *via* organizational resource brokers, we employ a single case study of a Louis Stokes Alliance for Minority Participation (LSAMP) alliance, a federally funded multi-institution alliance focused on racially diversifying STEM fields. As an SEP that facilitates interorganizational collaborations, this LSAMP alliance serves as an instrumental case of interorganizational resource brokerage and meets all of Small's (2006) characteristics of an organizational broker. First, by design, the LSAMP alliance interacts and partners with other organizations; it is made up of loosely coupled campus-based LSAMP programs and non-LSAMP partners that share divergent and collective interests (e.g., preparing students for graduate school), is subject to external pressures (e.g., federal funders), and has physical space at alliance institutions that become sites for student interaction.

Founded in the early 2000s, this LSAMP alliance comprises six postsecondary four-year institutions located in the Northeastern part of the United States. This alliance includes three public, land-grant, flagship universities, and three urban private institutions. This cross-institutional partnership shares a common goal of increasing the number of underrepresented racially and ethnically minoritized students (i.e., Black, Latina/o/x, Pacific Islander, and Native American) matriculating into, and successfully completing, high-quality undergraduate degrees in STEM. As a senior alliance that has successfully received several cycles of funding through the National Science Foundation (NSF), this LSAMP alliance is focused on increasing the number of racially and ethnically minoritized students pursuing graduate degrees in STEM. In addition to cross-institutional partnerships, this LSAMP alliance has also established strategic partnerships with non-alliance programs that facilitate entry into graduate school, including the National Graduate Degrees for Minorities in Engineering and Science (GEM) Consortium, Research Experience for Undergraduates (REU), McNair Scholars, other LSAMP alliances, and international partner universities, among others (**Table 1**). LSAMP participants have access to a wide range of goods and services, including but not limited to academic bridge programs, first-year experiences, networking events, peer mentoring, undergraduate research funding, research symposiums, and study abroad opportunities.

### Data Sources

This qualitative case study draws on a variety of data sources gathered from a larger longitudinal research project initiated in 2016 with funding from the NSF. The data sources that informed this case study include student interviews, informal interviews with program coordinators, and document analysis. Interviews with students regarding their participation in LSAMP were the primary data source. These interviews were conducted with the

**TABLE 1 |** Interorganizational LSAMP networks.

| LSAMP alliance institutions (6) |
|---|
| Non-alliance formal/Informal partnering organizations |
| GEM Consortium |
| NSF/NIH sponsored REUs (multiple institutions) |
| Society for Advancement of Chicanos/Hispanics and Native Americans in Science |
| International REUs |
| National Action Council for Minorities in Engineering |
| Discipline-specific national associations |
| National Society of Black Engineers |
| Society of Hispanic Professional Engineers |
| Society of Women Engineers |
| Industry partners |
| Non-alliance postsecondary institutions |
| LSAMP campus-based partners |
| McNair Scholars program |
| National Society of Black Engineers, local chapter |
| Society of Hispanic Professional Engineers, local chapter |
| Society of Women Engineers, local chapter |
| Science and engineering summer fellows |
| Bridge to Doctorate program |
| Research and mentorship programs |
| Living and learning communities |
| First year experiences |
| Academic achievement center |
| STEM Ambassadors |
| Offices of Undergraduate Research |
| Multicultural centers and offices |
| Summer Bridge |

LSAMP cohort that began their academic studies in 2016. Because one institution was a new member to the LSAMP alliance and did not have a cohort of students in the Fall 2016 semester, only five of the six alliance institutions took part in this study. Members of the research team conducted 30 one-on-one semi-structured interviews with students in the spring 2017 semester when students were in the second year of their academic studies. Research team members then collected 20 follow-up interviews during the spring semester of the students' fourth year in college (2020; **Table 2** for demographic information). While all students who took part in the first round of interviews were invited to participate in follow-up interviews, only 20 agreed. Approximately 3–10 students were interviewed at each institution (**Table 3**). Data were collected in person or *via* telephone and were audio recorded with the consent of participants. The interviews ranged between approximately 40 and 80 min in length. These semi-structured interviews included questions about students' involvement in LSAMP and how their participation in LSAMP shaped their educational and career trajectories. For example, students were asked about their involvements on and off campus that facilitated their educational and career goals, and how those involvements came to be (**Table 4** for sample interview questions). Informal interviews with LSAMP staff and administrators were also conducted to better understand the nature of the campus-based programs, including where the programs were organizationally situated within the university, the supports and services they provided to students, and how they worked with other partners on and off campus. Finally, program documents including evaluation and annual reports were collected and reviewed.

## Data Analysis

To analyze our data, members of the research team transcribed each audio recording and reviewed each transcript for accuracy. Then, we de-identified the transcripts by replacing students' names and other identifying information with pseudonyms. Next, we uploaded the transcripts to Dedoose, an online software used for conducting analysis of qualitative data. To begin the coding process, members of the research team worked collaboratively to develop a codebook. This step helped ensure a shared understanding of the codes that guided our analysis. Anchoring our data analysis was Small's (2006) framework of organizational resource brokerage. As an analytical tool, this framework informed the development of deductive codes that captured the types of resources students described accessing through their participation in LSAMP (e.g., information, goods, and services). We also created a series of process codes reflecting how these resources were brokered *via* the LSAMP alliance (e.g., passive/active and formal/informal transmission). For an overview of our coding scheme, please see **Table 5**.

Once these initial codes were established, two members of the research team carefully read and analyzed a subset of the interview transcripts using an interpretive approach (Denzin and Lincoln, 2008). We then came together to identify similarities and differences in our coding of these interview

**TABLE 2 |** First-year student profile of 2016–2021 LSAMP alliance cohort ($n = 30$).

| Pseudonym | Gender | Race/Ethnicity | Initial major |
|---|---|---|---|
| Abigail[a] | Woman | Black | Engineering |
| Ada[a] | Woman | Black | Engineering |
| Aliyah | Woman | Black | Biology and health sciences |
| Andre | Man | Black | Engineering[b] |
| Angel | Man | Latinx | Engineering |
| Angela | Woman | Black | Biology and health sciences |
| Antonio[a] | Man | Latinx | Biology and health sciences[b] |
| Awilda[a] | Woman | Black/Latinx | Biology and health sciences |
| Daniel | Man | Latinx | Physical sciences |
| David | Man | Black/Latinx | Engineering |
| Devan | Man | Black | Engineering |
| Doris | Woman | Black | Biology and health sciences[b] |
| Emilio[a] | Man | Latinx | Engineering[b] |
| Erica | Woman | Latinx | Biology and health sciences |
| Jada[a] | Woman | Black | Accounting |
| Jamal | Man | Black | Engineering |
| Jazmine[a] | Woman | Latinx | Engineering |
| Jordan | Woman | Latinx/White | Engineering |
| Joshua | Man | Black/Latinx | Biology and health sciences |
| Josie | Woman | Latinx/White | Engineering |
| Juana[a] | Woman | Latinx | Biology and health sciences |
| Keisha | Woman | Black/White | Engineering |
| Lorenzo[a] | Man | Latinx | Engineering |
| Luisana | Woman | Latinx | Engineering |
| Marco | Man | Latinx/White | Biology and health sciences[b] |
| Marisela | Woman | Black/Latinx | Engineering |
| Marquis | Man | Black | Digital media and design |
| Ofiong[a] | Woman | Black | Engineering |
| Ricardo | Man | Latinx | Engineering |
| Xavier | Man | Black/White | Physical sciences |

[a]*Denotes first-generation.*
[b]*Denotes transfer student.*

transcripts until discrepancies were resolved and a greater shared understanding of the codes was established. When coding discrepancies were encountered, the third author stepped in and served as a peer-debriefer (Saldaña, 2018). This step strengthened the codes and increased the credibility of our findings (Saldaña, 2018). In the second round of analysis, one member of the research team individually coded the remaining transcripts. During this process, we also engaged in axial coding which sought to uncover relationships and patterns across participants' responses. This led us to identify the themes discussed in our findings.

Because we are a multi-member team, continuous peer debriefing and the use of analytic memos capturing "emergent patterns, categories and subcategories, themes, and concepts" (Saldaña, 2018, *p*. 44) served as critical components in our analytical process. Specifically, the team used analytic memos (Saldaña, 2018) to help identify patterns and themes cutting across the LSAMP alliance. These memos included researcher notes and reactions, institutional profiles, and information about the types of resources brokered through LSAMP and non-alliance partners and the mechanisms through which the resources were brokered.

## Research Positionality

Race, culture, and prior life experiences impact the positionality of researchers and thus are important to discuss (Milner, 2007). This research study was conducted by Women of Color: two Latina women, and one Black woman. All three are researchers who broadly study the experiences of marginalized groups in STEM. Two authors are assistant professors of higher education, and one is a doctoral student studying higher education. As undergraduate students, we all participated in educational enrichment programs that sought to broaden minority participation in higher education. Additionally, one professor was a former administrator of an SEP program at a large public PWI. Collectively, our backgrounds as Women of Color who have navigated higher education and educational enrichment programs gave us unique insight into the participants'

**TABLE 3 |** Students interviewed by institution and type.

| Institution | Number of students interview 1 | Number of students interview 2 | Institutional size |
|---|---|---|---|
| A | 10 | 6 | Large |
| B | 6 | 5 | Large |
| C | 5 | 3 | Medium |
| D | 6 | 4 | Large |
| F | 3 | 2 | Large |

**TABLE 4 |** Sample interview questions.

1. Tell me about your current educational goals
2. Can you tell me about any experiences that you've had since you've started college that have reinforced your decisions to pursue an undergraduate degree in _____?
3. Tell me about your current career goals
4. What informed your decision to go directly into graduate/professional school/workforce?
5. Tell me about your involvement in LSAMP.
6. What has been most valuable about your participation in LSAMP?
7. How does your involvement in LSAMP relate to your educational/career goals?
8. Where/who do you go to when you need advice about your future in STEM (graduate school, careers in STEM, etc.)?

**TABLE 5 |** Sample coding scheme.

| Code | Code type | Description | Example |
|---|---|---|---|
| Resources Brokered_Information | Descriptive | Information provided by LSAMP | LSAMP provided funding for student participation in a conference |
| Mechanisms_Informal | Process | Informal ways resources are brokered by LSAMP | Meeting LSAMP peers and sharing information |
| Mechanisms_Formal | Process | Formal ways resources are brokered | LSAMP sent an email about an REU experience |

experience and the program's structure. We drew on our experiences throughout the research process, thus informing our data collection and analysis.

## FINDINGS

Two interrelated themes emerged from our analysis of the data. First, we found that LSAMP alliance institutions brokered social capital for SOCs in STEM by exerting influence on key educational processes and facilitating the flow of graduate school-related information that enabled the accumulation of educational resources (i.e., goods and services) to promote student aspirations and entry into graduate school. These resources were garnered through campus-based LSAMP programs, across the LSAMP alliance, and through partnering organizations. Second, students' abilities to both acquire and mobilize their social capital was predicated on the trust built between students and LSAMP staff.

### Brokering Science Technology Engineering Mathematics Graduate Opportunities

#### Influence

LSAMP students benefited from the authority of LSAMP staff both within and outside LSAMP alliance institutions. The influence exerted by LSAMP staff helped students access and retain important educational resources that supported their persistence in STEM. Students described how LSAMP staff bridged access to educational opportunities that they otherwise would not have access to. Ada, an engineering student, explained how the LSAMP director connected her to various opportunities. She reflected,

> He has definitely been able to help others I know connect with people in grad schools and just being able to network with the people that he knows. I know that I was interested in going to the (University) and he was like, "Okay, I'm gonna call my contact over there and see if I can set you up with somebody who is on the graduate academic board or something like that," or "I'm gonna see if I can connect you with somebody who does the type of research that you want to do and see if you can have a conversation with them."

Acting as bridges and writing letters of recommendation were the primary ways that LSAMP staff exerted their influence and extended their social capital on behalf of students. Through recommendations, staff tied students to other higher education institutions and partnering organizations. These letters of recommendation were important for securing research opportunities and graduate admissions.

#### Information

LSAMP also facilitated students' access to important information about graduate school. For example, the LSAMP alliance hosts the National GEM Consortium Getting Ready for Advanced Degrees Laboratory (GEM GRAD Lab) each year. The GEM GRAD Lab is an interactive conference for underrepresented undergraduate students that raises awareness about what graduate school is, how to prepare for it, and funding opportunities. It also provides networking opportunities with GEM graduate fellows. In essence, the LSAMP alliance's hosting of the GEM GRAD Lab was a way of transferring resources from the GEM Consortium to the alliance's students. Students often attended the GEM GRAD Lab early on during their undergraduate work, which was key for cultivating graduate school aspirations early on. Angel, an engineering student, attended the GEM GRAD Lab during his first year in college. He reflected,

> My friend and I were going to it. And we were like, why are we going to this? It's a graduate program. And we're barely through school. And then once we left, we were like, wow. That's actually really eye-opening. So that was my first exposure to really thinking about—I always viewed grad school as completely unaffordable. But then once you see all the funding that's out there, it makes it seem more achievable and attainable.

For Angel and his peers, the LSAMP alliance brokered informational resources that helped him learn about various options for funding graduate education. This information was "eye-opening" and expanded his educational options early on in his undergraduate career.

Some LSAMP programs also introduced students to information about undergraduate research and how to get involved in various educational opportunities that set them on graduate pathways. It was often through formal mechanisms such as first-year experiences, emails, and bridge programs that this crucial information was shared. Other students accessed information about research opportunities directly through advising from their LSAMP coordinator. For Xavier, a physical science major, LSAMP served as a bridge to an undergraduate research opportunity via referral. He explained,

> So, during my freshman year I went to my advisor at LSAMP, and I was just telling him about some of the research that I was interested in, and he pointed me in the direction of the (Research Lab). So what I did was I emailed someone that worked in the (Research Lab)— And yeah, we just went from there. I went to a meeting, and they got me set up to work within the (Research Lab).

For Xavier, and many other students, LSAMP introduced them to information regarding undergraduate research and served as a bridge to beginning high-impact educational experiences that were crucial for entry into STEM graduate programs. These included undergraduate research opportunities at the host institution, across the alliance, and at non-alliance institutions.

LSAMP also helped students navigate the graduate school application and decision-making process. Joshua, a biology and health science major, explained that he had multiple graduate school offers and was unsure how to make a decision. He spoke highly of his time in LSAMP and the community he gained through his participation, and he thus turned to the LSAMP director, Tina, for advice about how to select a graduate program. Tina taught him how to ask graduate programs about resources for SOCs, much like LSAMP. Joshua explained, “So, I made sure to ask that wherever I went. Some schools are a lot better at answering it than others. So I’m going to ask the question.” Tina provided Joshua with valuable information about how to determine if a graduate program would be a good fit and what resources it had for SOCs.

Information was also brokered through informal mechanisms. Campus-based LSAMP programs provided a physical gathering space for students to connect and form relationships with other SOCs in STEM. Many students formed deep friendships with fellow LSAMP students where additional information was brokered. For example, Doris, a biology and health science major, described how her LSAMP peers shared graduate school-related information:

> I just found out that you can actually—there’s a way you can apply for a fee assistance program to apply to medical school. I think . . . the point of networking is really just learning about resources you wouldn’t otherwise know about from a bunch of your friends.

From friendships she cultivated through LSAMP, she accessed information that would facilitate her entry into medical school.

### Goods

Beyond facilitating information sharing, LSAMP served as a resource broker for goods that facilitated graduate opportunities. Through the LSAMP alliance, students had access to funding opportunities to conduct research abroad through International Partnerships. These international research experiences equipped students with valuable skills and expanded their worldview. Joshua, a biology and health science major, explained, “(T)he program paid for us to do immersion trips every weekend. Every weekend we’re traveling somewhere else around China to do things.” LSAMP helped remove financial burdens and opened doors to new opportunities. For Keisha, an engineering student who struggled with connecting to engineering and to her university, her international research experience connected her to the field and supported her persistence in STEM. She reflected,

> I was able to get money through the research internship that I’ve done, and then, sometimes, if we’re doing research on campus Dean (Anderson) can pay us through the LSAMP funding. So, the funding has just been super helpful. Because that’s funding that I don’t get anywhere else.

The funding LSAMP provided was key for many students in gaining the research experience necessary for entry into graduate school. Through these research experiences, students gained valuable skills to add to their resumes, developed relationships with faculty, and enhanced their graduate school aspirations.

The funding from LSAMP came in many different forms. At some universities, students had access to book scholarships when they participated in LSAMP events. For others, the funding was brokered passively through association with LSAMP. Joshua explained, “Because I’m in LSAMP, that waived the (graduate) application fee for every university except for Harvard, which was amazing.” Joshua’s participation in LSAMP brokered goods that directly supported his entry into graduate school. Antonio, a biology and health science student, discussed the many funding opportunities related to graduate school that LSAMP brokered:

> I’ve still got a GRE book. You know, I’ve got these free waivers for me to take the GRE. (...) In LSAMP, the benefits are . . . what (David) can help you out with. Like he can give you a GRE book. He could help you out, get some waivers and could give you advice and help you out to go to study abroad or help you get your paper presented at (Institution A).

The various funding opportunities that were available through LSAMP, and in association with LSAMP, helped broker graduate opportunities for students.

### Services

LSAMP served as a bridge to connect students to other graduate school-related services. For many students, LSAMP connected them to other SEPs and institutional services that were vital in brokering graduate opportunities. Ricardo, an engineering student, explained how LSAMP served as a bridge to the McNair Scholars program, where he received a faculty mentor, was exposed to graduate programs, and gained access to services that helped prepare him for graduate school. He reflected,

> And through LSAMP I really learned a lot about opportunities, to be honest. I actually did the McNair fellows last May and that pushed me to apply to be a McNair Scholar, and I’m currently a McNair Scholar. So

> definitely LSAMP has exposed me to different opportunities, particularly looking into research and graduate school, because that's really like the push for LSAMP, and I guess what McNair pushes for.

It was through his participation in an LSAMP-sponsored first-year experience (FYE) that Ricardo and peers were introduced to the McNair Scholars program and he was able to access additional formal services related to graduate school.

Other students accessed valuable services related to graduate school through the annual LSAMP symposium. Students explained that by attending this annual symposium with the LSAMP alliance, they had the opportunity to present their research, network with STEM students across alliance institutions, and learn more about graduate school. For David, an engineering student, this annual symposium strengthened his graduate school aspirations. He reflected,

> (B)efore I thought I could, you know, go to school, just get my master's, like, do the B.S./M.S. program, but not even do the B.S./M.S. program, just get my bachelor's, and be done with it and go into the workforce. But then because of the first poster symposium I went to, I switched to the B.S./M.S. program, and then the next one that I got to I, yeah, I got some more information about the Ph.D., and I keep going to them, I learn more and more about, you know, getting my Ph.D.

For David, and many other students, their participation in their campus-based LSAMP program served as a bridge to the resources embedded within the LSAMP alliance. This annual symposium had a critical influence on many students' perceptions of graduate school. According to an internal annual LSAMP report, a total of 29 students attended the symposium and were surveyed afterwards. Of those surveyed, 55% planned to apply for graduate school, 10% had already applied, and 3% had already been accepted into a graduate program. The majority of the students who attended the LSAMP alliance symposium had graduate school aspirations. This is consistent with interview data in which many students shared how this symposium initiated or reinforced their aspirations to attend graduate school.

## Efficiency of Brokering Resources

Our findings also revealed that trust was key to accessing resources embedded within LSAMP interorganizational networks. Many participants had strong relationships with LSAMP staff that allowed them to seek graduate school-related advice and become connected to important educational resources that ignited and sustained their graduate school aspirations. Interrelated with trust was how LSAMP instability shaped students' abilities to leverage resources embedded within the LSAMP alliance. For LSAMP students attending institutions with high staff turnover or organizational change, their inability to build trusting relationships with LSAMP staff impacted their ability to both acquire and mobilize their social capital.

### Cultivating Institutional Trust

Many LSAMP staff earned students' trust by demonstrating care for both students' well-being and their educational success. Marco, a biology and health science major, explained, "(T)he connection came from just knowing that he was really concerned with me as an individual succeeding at this institution. Having that moral support allowed me to have trust in David and hear what he had to say." Many students expressed similar sentiments. For Joshua, trust began with a shared experience and was cultivated over time. Joshua described how LSAMP provided him a sense of community that helped build trust and access the resources provided. Joshua reflected,

> (T)his was the first time I saw other people that looked like me, when I joined LSAMP. And that was a big thing for me, where I hated feeling different. And now I was in with other people where I didn't feel different.

Joshua's involvement with LSAMP was influential in providing him a community with other Students of Color and Scholars of Color. This helped Joshua develop a strong relationship with the LSAMP director, Tina. He shared, "She was also one of the few Black PhDs that I knew at (Institution D)." Their shared racial identity helped him trust Tina and turn to her for advice. He reflected,

> It just helped me a lot to open up and to talk with her because . . . It always felt like she was just always very genuine. She treated me like I was one of her kids. It was nice to have that loving figure in a new place where I didn't really look like other people.

Their common background helped serve as the foundation for trust that allowed Joshua to access many helpful resources related to graduate school.

Trust also shaped who students turned to when seeking various forms of support. For many students, LSAMP was a space they trusted more than institutional resources available to all students. Angela, a biology and health sciences student explained, "I know I could use other resources on campus, like the Career Development Center or similar services. But I guess since I had a more personal relationship with David, he could give me more personalized advice." Angela knew there were university resources available to help with her resume and cover letters; however, she trusted David and had built a personal relationship with him that influenced her decision to turn to him, rather than the career center.

### Louis Stokes Alliance for Minority Participation (In)Stability and Resource Brokerage

While many students found LSAMP to be a place they trusted for support and resources, there were also students who were unsure of LSAMP's role and their involvement in the program. Some campus-based LSAMP programs experienced high staff turnover and organizational instability. For example, most of the students interviewed at Institution C had participated in a pre-orientation program sponsored by LSAMP; however, most were unaware of what it meant to participate in LSAMP beyond the pre-orientation program. Aliyah, a biology and health science student, was unsure how she became connected with LSAMP. She reflected,

> So, I think the reason why I was part of LSAMP was because of the (Office of Multicultural Affairs), because I know that they do work with LSAMP closely? I'm not 100% sure of the whole process and everything. And I want to say (pre-orientation program) is also part of it, but I could be wrong. I think that's why I'm more involved in it. (...) I'm not 100 percent sure, because it's been like, rerouting everywhere.

Aliyah's reflections were consistent with how students at Institution C perceived LSAMP. Many students explained how the restructuring and staff turnover contributed to their lack of involvement. Similarly, Luisana, an engineering student, was initially involved in LSAMP; however, due to organizational restructuring, her involvement never progressed past the pre-orientation program. She explained,

> I applied, and then they never got back to me. I applied, and you're supposed to get interviewed. And then I didn't get interviewed. I just got an email like, I'm sorry. You weren't accepted—They've gone through two changes recently at the Office of Multicultural Affairs, so it's been shaky.

The organizational instability within Institution C's LSAMP program created confusion and a lack of understanding regarding students' involvement in LSAMP and the resources LSAMP could provide. However, LSAMP institutions that had strong organizational ties and that were connected with offices that had a similar mission were able to increase trust and serve as bridges to graduate school-related resources.

## DISCUSSION

Findings from this study reveal that SOCs in STEM benefit from passive and active transmission of social capital facilitated through LSAMP alliance institutions and their interorganizational network. Extending Small's (2006) framework to the study of higher education institutions sheds light on how colleges and universities broker graduate opportunities through making resources embedded in interorganizational networks accessible to individuals. This framework proved useful for examining how the LSAMP alliance actively and formally brokered resources for SOCs in STEM seeking to access graduate school. For example, we uncovered how LSAMP alliance institutions utilized their interorganizational network to broker graduate school-related resources such as graduate school application fee waivers and access to graduate school-related workshops. This framework also highlighted a myriad of ways LSAMP enables SOCs to develop and accumulate social networks that are critical to identifying resources, information, and individuals who can help them navigate the graduate school application process and eventual admission into graduate education. The more we know about how SEPs broker social capital for SOCs, the more we can systemize and formalize these processes to make them more efficient and likely to result in greater success for SOCs in STEM undergraduate programs. In line with Small's (2006) organizational brokerage theory, the ability to cultivate institutional-individual trust became foundational for brokering social capital. To that end, students were more likely to inquire about graduate school-related issues with LSAMP administrators than with administrators and faculty outside of LSAMP. However, we learned that the instability of some LSAMP programs threatened to fracture this trust, and ultimately to impede access to important graduate school-related resources.

LSAMP participants were also able to establish informal networks with students and institutional agents who were instrumental in accessing graduate school information and other forms of social capital. Formal and informal networks afforded through LSAMP and its interorganizational networks enabled SOCs to extend their networks and obtain resources that were not readily available to them outside of their program affiliation (Lin, 1999; Small, 2006). Program participants bridged relationships and connections to fortify a seamless pathway to graduate school (Dika and Martin, 2018). As such, participants easily accessed program leaders and fellow students to get information and resources and used these networks to tap into other networks for support. Their affiliation with LSAMP also enabled them to acquire goods and services necessary to meet their graduate school aspirations. For example, LSAMP administrators facilitated opportunities for students to formally join McNair programs, or informally attend graduate school-related workshops sponsored by McNair. In these ways, connecting students to resources, people, and information promoted formal and informal transmission of capital.

Our data also revealed that passive forms of capital transmission are just as important as more active forms. Doris, for example, learned through an informal interaction with a peer student that there was a fee assistance program for medical school. These types of chance interactions are afforded through participation in programs like LSAMP (Lane, 2015; Maton et al., 2016). Even mundane, taken-for-granted knowledge can have a resounding impact on one's pathway toward post-graduate education. Thus, program leaders should continue to create structured and formal opportunities for students to build relationships and community with one another in order to facilitate informal transference of capital.

Signature events such as the GEM GRAD Lab allowed program leaders to provide information about pathways to graduate school (e.g., application process, funding) early in students' undergraduate careers. Sanders and Landrum (2012) discovered that students in their senior year of college knew relatively little about the graduate admissions process. They concluded that approaches to preparing undergraduate students for the graduate admissions process are insufficient.

In contrast, our study showed that GEM's early exposure to graduate school-related knowledge fostered participants' aspirations and made them better prepared to apply for and transition into graduate school when the time came. Strategies such as these contribute to a smoother transition into graduate school for LSAMP students compared to students who may not have access to this information early in their college career, if ever. These types of systematic advantages afforded through LSAMP are critical to groups that have been historically disenfranchised in graduate education. For example, Ramirez (2011) interviewed 24 Latina/o/x doctoral students who indicated that "no one taught (them) the steps" for accessing graduate school (*p.* 204). "Because (graduate) education is the gateway to research careers and the professoriate," campus leaders cannot leave learning about graduate school to chance if we are to broaden participation in the academy (Ramirez, 2011, *p.* 205). Likewise, as Sanders and Landrum (2012) illustrate, it cannot be assumed that other institutional actors and units will disseminate information about graduate pathways.

LSAMP students also benefited from bridging multiple programs and high-impact practices, including McNair, GEM GRAD Lab, research abroad, and other undergraduate research experiences. In the literature, high-impact practices, also known as HIPs, are in-depth learning experiences that require substantial time and dedication from students and faculty involved in them (Kuh, 2008). Students who engage in HIPs perform better academically, have higher rates of degree completion, have stronger critical thinking skills, and tend to value challenging and stimulating cognitive experiences (Kuh, 2008; Finley and McNair, 2013; Kilgo et al., 2015; Kuh et al., 2017). Not only are these outcomes beneficial for enriching a student's undergraduate career but engaging in HIPs can make students more competitive for graduate school (Strayhorn, 2010; Eagan et al., 2013). There is also some evidence that HIPs are more meaningful for underrepresented students (Finley and McNair, 2013), although they tend to participate in them at a lower rate than their majority counterparts (Kuh et al., 2017). This may be due to systemic and structural inequities in some institutional contexts that create roadblocks for SOCs and their capacity to access HIPs (Patton et al., 2015). Some of these stem from faculty who fail to engage students in undergraduate research or support their access to internships, thus limiting opportunities to transmit discipline-specific knowledge (McCoy et al., 2017). As such, serving as a conduit for HIPs demonstrates another way that SEPs broker opportunities that are crucial to graduate pathways.

LSAMP aided students in brokering material goods such as funding for research abroad that enhanced students' credentials and cultural capital, contributing to favorable outcomes in the graduate admissions process. Additionally, students reported receiving fee waivers for graduate school applications. The cost to apply to graduate school can create unique barriers for students. Application fees, standardized tests, and costs associated with graduate school visits can all be deterrents to applying to graduate school, especially for students who are considering graduate school amid substantial undergraduate debt (Malcom and Dowd, 2012). The resources provided through LSAMP lessens these burdens, increasing the likelihood that students will be well-positioned to apply. The value of these forms of cultural and economic capital cannot be overstated; further study into how SEPs mitigate financial barriers to graduate STEM pathways is warranted.

This study points to trust as a critical factor in SOCs seeking out and being receptive to advice and support for accessing graduate education. Students valued the connection and sense of community gained through LSAMP. Consequently, they were more likely to engage program leaders when trying to understand pathways to graduate school. Other researchers have pointed out the significance of institutional agents who develop trusting relationships among SOCs in educational contexts as a precursor to addressing their needs (Deil-Amen, 2011; Museus and Neville, 2012; Dika and Martin, 2018). This finding is also consistent with the finding from Ream et al. (2014) that trust may matter more to STEM SOCs than to their White counterparts, especially relative to their motivation and career expectations. Our study confirms previous research concerning the criticality of trusting relationships in the process of brokering resources and information for graduate STEM pathways. One manner in which trust is earned is through "solidarity and shared meaning in the context of institutional realities" (Stanton-Salazar, 2011, *p.* 1088). SOCs, in the current study, reported feeling more at ease when obtaining information because they recognized programs leaders had their best interest in mind. Program leaders, some of whom were People of Color with STEM graduate degrees, uniquely understood the context in which the students were navigating graduate pathways. This shared solidarity and identity also played a role in building trusting relationships. Our data also revealed that students were more likely to inquire about and accept help from LSAMP administrators than they were from staff in the general university. This finding speaks to the need for and relevance of STEM enrichment programs as well as why they should be sustained on college campuses. The personal relationships SEP administrators foster with students are guided by an ethic of care and strategies found in otherparenting (i.e., wherein institutional agents take on culturally relevant, parent-like behaviors) (Lane, 2015; Lane and Id-Deen, 2020). Studies show that caring and otherparenting approaches advanced within these programs are responsible for retaining many SOCs in STEM (Lane, 2015; Lane, 2016; Lane and Id-Deen, 2020). On the other hand, our study also uncovered that instability in these programs may impede trusting relationships between administrators and students.

Participants in our study noted the impact of staff turnover and how it created unstable SEP environments. There are a myriad of factors that influence the stability of SEPs. One is the cost of running them (Watford, 2007; Koenig, 2009). If federal funds are not available, such as the case with LSAMP, these programs may cease to exist. Many colleges and universities may not have the resources or desire to sustain these programs without external funding sources (Rincón and George-Jackson, 2016). Staff also tends to be limited (Shehab et al., 2012). If a staff person receives a promotion or departs the institution, these units can become understaffed.

Consequently, access to graduate school-related resources embedded within these interorganizational networks can be easily jeopardized.

## IMPLICATIONS

The findings from this study offer important implications for future research and practice. One area ripe for further inquiry relates to how program instability coincides with a student's ability to build trusting relationships with SEP staff, thus impacting an SEP's ability to transmit social capital. Future research could examine how different organizational contexts shape the efficiency of brokering social capital, examining, for example, how SEPs are funded, where SEPs are situated organizationally within an institution, and how the stability of an SEP is likely to impact its ability to broker educational opportunities. Further, future research could investigate how SEPs broker other important student outcomes beyond pursuing graduate education opportunities. For example, we know that SOCs are able to develop important social networks in STEM while in college, but less is known about how they mobilize and maintain these networks to garner educational and career opportunities post-graduation.

The findings from this study position LSAMP programs as exemplary models for other educational programs looking to support SOCs in STEM. Central to LSAMP's success is the intentional partnership among diverse postsecondary institutions that comprise the alliance, campus-based partners, and non-alliance partners. In particular, the LSAMP alliance demystifies the graduate plan of study by "spelling out" the formula for student success, thus offering seamless transitions to graduate school for SOCs. Students are provided early exposure to educational information that makes graduate opportunities known and attainable for SOCs, educational goods and services that provide students with educational exposure, opportunities that provide a competitive edge when applying to graduate school, and formal and informal networks that support the cultivation of important networks of peers who have similar backgrounds and aspirations. Moreover, SEPs are successful at bridging students' access to educational resources because they do so in culturally responsive ways. That is, SEPs recognize the importance of fostering relationships with students in order to counter the historical mistrust between SOCs and postsecondary institutions, especially PWIs.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors upon request.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by IRB, UNLV. The participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

AG, TL, BR contributed equally to this work. All authors contributed to the first draft of the paper and took the lead on the different sections. All authors contributed to manuscript revision, read, and approved the submitted version.

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# Supporting Student Success and Persistence in STEM With Active Learning Approaches in Emerging Scholars Classrooms

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Over the last several decades, Emerging Scholars Programs (ESPs) have incorporated active learning strategies and challenging problems into collegiate mathematics, resulting in students, underrepresented minority (URM) students in particular, earning at least half of a letter grade higher than other students in Calculus. In 2009, West Virginia University (WVU) adapted ESP models for use in Calculus I in an effort to support the success and retention of URM STEM students by embedding group and inquiry-based learning into a designated section of Calculus I. Seats in the class were reserved for URM and first-generation students. We anticipated that supporting students in courses in the calculus sequence, including Calculus I, would support URM Calculus I students in building learning communities and serve as a mechanism to provide a strong foundation for long-term retention. In this study we analyze the success of students that have progressed through our ESP Calculus courses and compare them to their non-ESP counterparts. Results show that ESP URM students succeed in the Calculus sequence at substantially higher rates than URM students in non-ESP sections of Calculus courses in the sequence (81% of URM students pass ESP Calculus I while only 50% of URM students pass non-ESP Calculus I). In addition, ESP URM and ESP non-URM (first-generation but not URM) students succeed at similar levels in the ESP Calculus sequence of courses (81% of URM students and 82% of non-URM students pass ESP Calculus I). Finally, ESP URM students' one-year retention rates are similar to those of ESP non-URM students and significantly higher than those of URM students in non-ESP sections of Calculus (92% of ESP URM Calculus I students were retained after one year, while only 83% of URM non-ESP Calculus I students were retained). These results suggest that ESP is ideally suited for retaining and graduating URM STEM majors, helping them overcome obstacles and barriers in STEM, and increasing diversity, equity, and inclusion in Calculus.

**Keywords: emerging scholars program, building community, active learning, calculus, retention**

# 1 INTRODUCTION

West Virginia University (WVU) received a National Science Foundation Louis Stokes Alliance for Minority Participation grant as part of a ten-institution alliance in Kentucky and West Virginia (KY-WV LSAMP) beginning in 2006. This grant provided a mechanism for programming to support the success of underrepresented minority (URM) students, to increase retention of these students in mathematics classes and, in turn, to support them through their STEM majors. A variety of activities related to the goals of the LSAMP program have been implemented at WVU over the years. In 2009, two WVU mathematics faculty members participated in a Professional Enhancement Program (PREP) workshop hosted by the Mathematical Association of America (MAA) on developing and implementing Emerging Scholars Programs (ESPs) and decided to embed the program in calculus as a focal point for the WVU LSAMP efforts to facilitate student success and persistence in STEM.

The concept for ESP was developed at the University of California at Berkeley in 1977 out of a desire to increase diversity in their student population. Uri Treisman observed that students in some (primarily Asian) minority groups had created their own small learning communities (Asera, 2001; Hsu et al., 2008). Students in these communities supported each other's mathematical understanding by working together to prepare for classes, complete assignments, and study the material while students from other minority backgrounds traditionally underrepresented in STEM fields often struggled to flourish in the mathematics courses they encountered (Asera, 2001). Treisman acted on a conjecture that one of the core problems facing many URM students in their academic work is the lack of a community with shared experiences. Students who lack community support as they move through their academic programs may experience isolation and disconnects that pose significant barriers to success. In a community of peers, the development of mathematical ideas can happen in ways that stem from cultural similarities. ESP implementations build communities of students around shared experiences and identities to mitigate a sense of isolation and have been shown to increase success among URM students (Fullilove and Treisman, 1990; Bonsangue and Drew, 1995; Moreno et al., 1999).

# PEDAGOGICAL FRAMEWORKS AND PRINCIPLES

The traditional ESP model developed by Treisman recruited URM students for out-of-class problem sessions in which groups composed primarily of URM students worked on challenging mathematics problems on blackboards in an engaged classroom (Asera, 1988). Groups worked simultaneously on the same problems and were able to watch the progress of the other groups. During these sessions, which were scheduled multiple times per week for a total of four to six hours of out-of-class work, each group presented their work on specific problems and interacted with other groups. These sessions were very successful in elevating URM students to a similar performance in Calculus as non-URM students (Hsu et al., 2008). Prior to attending the PREP workshop, out-of-class Calculus Seminars had been developed at WVU to increase engagement and provide extra support for students in calculus, but the sessions were not targeted specifically to any particular demographic. The sessions were not compulsory for any students and were not regularly attended. The faculty investigators at WVU then decided that a specially designated section of ESP calculus could be implemented and utilize inquiry-based learning methodologies to immerse students in a community of learners.

After attending the MAA PREP workshop on ESP and based upon experiences facilitating supplementary problem sessions in Calculus, we integrated problem sessions into the class structure to build small learning communities for URM students in STEM disciplines. At the time, no reports of integrating an ESP-style structure into the daily class sessions had been reported at any other institution. The innovative structure would create engaged learning communities in every aspect of the course, not separate from the lectures. The students would spend the majority of their time developing the concepts of Calculus and interacting with their communities to master the material.

The success of traditional ESP was based on a structure of small communities of students working on sets of problems out-of-class as a supplement to the discussions of solutions to problems as an entire class. We designed this to be a central aspect of the WVU ESP Calculus class while keeping the small communities intact. By doing this, we were building learning communities of URM Calculus students of three or four students with periodic whole-class discussions. In those whole class discussions, the small communities worked together to present their solutions.

## Standards and Competencies for ESP Students

Our implementation of ESP in Calculus established a number of classroom and community norms in order to create a safe, professional atmosphere that cultivates learning. Students work as a group, deriving conceptual ideas of the topic, building procedural knowledge, giving presentations in the class and taking assessments that test both procedural and conceptual learning. Course faculty clearly articulate expectations for group learning, and the classroom facilities are configured to optimize the group learning dynamic (i.e., setting up tables and chairs for group work, creating space for presentations like whiteboards, markers for each group, etc.). In addition, groups are expected to present their work, while other students supportively engage in small group and whole class discussions. This is done by establishing an environment of constructive feedback and encouragement. Finally, students are asked to present clear solutions in all forums. Within this format of formal presentation and real-time, respectful feedback, it is observed that students can make adjustments to their work towards mathematical accuracy (i.e., using equal signs, using correct notation, showing sufficient amount of work to support conclusions), and in turn towards mathematical understanding. As the semester unfolds and students become acquainted with the professionalism of the ESP Calculus experience, they come to know that any group member may be called upon to present the group's solution to a problem. These expectations work to build a learning community with the goal of maximizing every student's success.

Competencies for the ESP Calculus class are three-fold. First, students should gain a solid understanding of typical Calculus problems. Second, students should not memorize formulas, but they should know the answer to why the mathematics works. Last, students should know how to apply the knowledge and understanding they have built in Calculus to solve non-routine and more challenging problems, which can accelerate students to the next level of both conceptual and procedural understanding.

## LEARNING ENVIRONMENT

Working with Department, College, and University administration, space within the department was identified and renovated to support the active learning environment for the course, and recruitment efforts were launched to identify students for the course. Given the university demographics, we extended recruitment efforts beyond URM students to include first-generation students (the institution defines a first-generation college student as a student for whom neither parent had completed a four-year college degree) to include other students who could potentially benefit from community building. All students eligible for Calculus who met the URM and/or first-generation requirement were invited to enroll in the course through a personalized letter from the director of the program that was sent by e-mail and postal mail to their home address. All interested students were accepted into the course, though not all eligible students elected to enroll. Half of the students enrolled in the section were URM or first-generation college students. Recruitment efforts effectively interacted with WVU's population of URM and first-generation students though only a small number of those students enrolled in the course and so other students were invited. The first ESP calculus course was then taught to 24 students in the Fall 2009 term. The two MAA PREP participants were designated as the course's primary and secondary instructors, and a graduate assistant was assigned to provide further direct student support and attend each class session. The ESP section was scheduled to meet for two-hour sessions three times per week, rather than one-hour sessions four times per week. The team set a schedule of weekly out-of-class meetings and teams of students, referred to as *learning communities,* were formed for each class session. To support ongoing community ties, instructors were assigned to Calculus I and stayed with the same cohort of students from Calculus I through Differential Equations. Since the inaugural ESP Calculus class, URM students have been the primary focus of recruitment using personalized letters, while filling up any remaining seats with first generation students. Due to space limitations of the renovated ESP Calculus classroom, at most twenty URM and first-generation were recruited for the ESP Calculus classes (compared to 30–40 for the traditional Calculus classes).

**Worksheet 28**
Math 155 – ESP
October 31, 2020

1. Think of a way you can rewrite inverse trigonometric functions. **Derive the derivative rules** for, $y = \sin^{-1} x$, $y = \cos^{-1} x$ , $y = \sec^{-1} x$, and $y = \tan^{-1} x$. Outside of class you should derive the derivative rules for $y = \csc^{-1} x$ and $y = \cot^{-1} x$. Recall that we can also write $y = \sin^{-1} x$ as $y = \arcsin x$, and similarly for the other inverse trigonometric functions.

2. Using the rules derived in #1 and the other derivatives rules you have learned, **find the derivatives** of the following.
(a) $f(x) = 2\sin^{-1}(x-1)$
(b) $f(x) = \text{arcsec}\, 3x$
(c) $f(x) = x^2 \arctan x$
(d) $f(x) = \frac{\cos^{-1} x}{x+1}$
(e) $f(x) = \cos(\text{arccot}\, x)$
(f) $f(x) = e^x \arctan\left(\frac{1}{x}\right)$
(g) $f(x) = (1+x^2)\ln(\arctan x)$
(h) $f(x) = x\arccos(x) - \sqrt{1-x^2}$

3. Using **implicit differentiation** to find the tangent line to the graph of $\arcsin(x+y) + \arcsin(y) = \frac{\pi}{2}$ at the point (1,0).

4. **Prove** that
$$\arcsin x = \arctan\left(\frac{x}{\sqrt{1-x^2}}\right)$$
for $|x| < 1$. (Hint: Think about Calculus).

**FIGURE 1 |** Sample ESP worksheet.

Because the instruction was inquiry-based, there was no textbook for ESP Calculus and most class sessions followed a format of engaged learning. That format began with a short interactive review followed by an intensive sequence of pointed questions to construct new concepts. This instructor-focused portion of the class was intentionally short-often no more than ten minutes. Then, a problem set was distributed, and student work began. In their small learning communities, students would be given a basic concept-building block and then asked to complete exercises and solve problems to develop the idea. The work was overseen by a graduate student and two instructors who circulated the room, and most often responded to questions with questions in an engaged dialogue. Exams for Calculus, including the ESP section, were written and administered uniformly by the Department. This provision allowed for easy ongoing comparisons of student progress by the course instructional team as well as more thoughtful deliberation on the course's structure going forward.

To build a learning community in Calculus I for a given set of students, we started by dividing students into groups of three or four students. Each group member brought their own perspective and their own unique strengths in mathematics to complement those of the others. Working on a set of problems within a given topic in Calculus, the small groups encountered a range of problems designed to build conceptual understanding, problems similar to those common in textbooks, and problems that combined multiple principles and challenged students to a build a broader understanding of the material (**Figure 1** for a sample of problems from part of one of the worksheets on derivatives of inverse trigonometric functions). At different points in each class, groups were asked to present solutions to the entire class, answering questions from other students and addressing comments. These class discussions were structured similarly to colloquium talks in that students were given constructive criticism from the instructional team. To formalize the process, a theme of mutual respect was introduced and reinforced early in the term; presenters were thanked with applause and students were encouraged to give presenters constructive criticism and comments. These supportive components of the learning environment were essential to building notions of mutual respect leading to productive discussion that included all students. Near the end of most class sessions, especially when a few problems remained unsolved from the worksheet, groups were assigned out-of-class work and asked to be prepared to present solutions at the beginning of the next class. In addition, individual student work was assigned as a set of homework problems.

Worksheets were designed to cover problems that provoked students to build material from the basic conceptual elements. In addition, to achieve the desired level of understanding, after working through those basic conceptual elements, groups worked on a variety of problems to further reinforce the connections with more traditional Calculus problems as part of an engaged learning community in which they felt safe. This reinforcement comes about from working with each other to develop detailed and clear solutions to problems and explaining strategies and concepts to other groups.

## Learning Objectives

As noted above, the learning objectives for the ESP Calculus sequence includes both content and skill-oriented outcomes as well as meta-cognitive development. Students should gain a solid understanding of typical Calculus problems that involve concepts and skills identified in traditionally accepted calculus courses. As noted in Hughes-Hallett (2006), a primary goal for students is to develop conceptual understanding. Within that, the learning objectives for ESP align with those identified by experts surveyed in Sofronas et al. (2011) and cover conceptual and skill mastery core concepts for introductory calculus students within the topic areas of limits, derivatives, applications of the derivative, and integration. Our approach was built around the notion that students should not memorize formulas, but they should be able to communicate the ways in which the mathematics works. That is, they should be able to derive (or prove) the concepts in Calculus. Once a student has developed a conceptual understanding of Calculus, they will then be able to recall formulas and derivations—or build them from that understanding—when needed. In addition, they can concentrate on applying concepts to a variety of different problems. Finally, Sofronas et al. (2011) also observe that calculus students should develop connections and relationships between concepts and skills, and apply the knowledge and understanding they have built in Calculus to solve non-routine and more challenging problems. This last step can accelerate students to the next level of both conceptual and procedural understanding as it leads to higher levels of meta-cognition and the ability to transfer knowledge to new situations.

## Data and Results

West Virginia University is a Research I institution in the Eastern United States with a primarily white student body population. Calculus I covers differential Calculus (limits, derivatives, and applications of derivatives) and introduces Integral Calculus. A full treatment of Integral Calculus is covered in Calculus II.

**TABLE 1** | Demographics of participants.

| | Participants | General student population |
|---|---|---|
| Number of students | 138 | 6,894 |
| URM | 60% | 8% |
| Women | 33% | 30% |
| First-generation | 24% | 15% |

## Participants

The participants in this study were students in ESP Calculus between 2009–2019. During this time, 138 students enrolled in ESP Calculus I, 60% of them URM, 33% of them women, and 24% of them were first-generation students (**Table 1**). During the same period, 6,894 students enrolled in the traditional Calculus I course, 8% of them URM, 30% of them women, and 15% of them first-generation students. Most participants in the study were STEM majors (96%) with the majority being Engineering majors (67%), consistent with the university's overall major trends. Most participants were freshman (80%).

# METHODS

This work explores the success of students both in passing a college mathematics class and in continuing in college one year after completing the mathematics class. Both outcomes are dichotomous and are explored within the framework of logistic regression.

The logistic regression models developed here allow the comparison of the effect of a treatment on some outcome controlling for a set of background variables. We model the impact of the change to the ESP classroom approach on a number of student outcomes including pass rates and persistence and use these models to estimate the likelihood or odds of improved outcomes if a student is present in an ESP class. We can then compute the odds ratio for these outcomes, namely the ratio of the odds of a successful outcome in ESP to the odds in other classes. If the odds ratio (OR) is greater than 1, then a one unit increase in the variable represents a $100\%^*(OR - 1)$ increase in the odds of the positive outcome. If the odds ratio is less than one, then a one unit increase in the variable increases the odds of the negative outcome by $100\%^*((1/OR) - 1)$; the odds of the negative outcome is the inverse of the odds of the positive outcome.

## Analysis and Outcomes

This quantitative analysis will focus on Calculus I, which serves the largest cohort of students requiring any version of calculus at our institution (versions of business calculus and slower-paced calculus are available for students at our university depending on their major but serve fewer students). We explore the rate at which students pass Calculus I (defined as earning a C or higher),

**TABLE 2 |** Descriptive statistics.

| | N | HSGPA | ACTM% | Percent passing | Percent retained |
|---|---|---|---|---|---|
| ESP calculus I | | | | | |
| Non-URM | 55 | 3.85 ± 0.5 | 83 ± 12 | 82 | 84 |
| URM | 83 | 3.63 ± 0.5 | 80 ± 15 | 81 | 92 |
| Calculus I | | | | | |
| Non-URM | 6,366 | 3.71 ± 0.5 | 78 ± 16 | 63 | 86 |
| URM | 528 | 3.41 ± 0.5 | 67 ± 20 | 50 | 83 |

and the rate at which students in the class are still enrolled in college one year after completing the class (the 1-year retention rate) for ESP Calculus I and regular Calculus I. For most students taking Calculus I, a grade of C is required to progress in their majors. Students' general academic preparation was characterized by their high school GPA (HSGPA) and their ACT or SAT mathematics percentile score (ACTM%). **Table 2** presents descriptive statistics and values presented are the mean (M) ± standard deviation (SD).

**Table 2** shows that students in the ESP course have generally superior high school preparation as measured by ACTM% or HSGPA than students in the traditional calculus course. For the remaining analysis in this work, we focus on the results for URM students; future work will explore the effect on first-generation students. The difference in HSGPA and ACTM% between URM and non-URM students in the ESP course was also lower than students in the traditional calculus course. In traditional calculus, URM students pass the class at a significantly lower rate ($\chi^2$ (1) = 32.74, $p$ < 0.001) and are retained a significantly lower rate ($\chi^2$ (1) = 5.63, $p$ = 0.018) than non-URM students. In ESP calculus, URM students pass the class at the same rate ($\chi^2$ (1) = 0.00, $p$ = 1) and are retained at the same rate ($\chi^2$ (1) = 1.33, $p$ = 0.249) as non-URM students. The differences in passing rate between the two classes is also significant ($\chi^2$ (1) = 26.36, $p$ < 0.001) as is the difference in one-year retention rate (at the $p$ < 0.1 level) ($\chi^2$ (1) = 2.89, $p$ = 0.089). For URM students, the difference in passing rate between the two classes is also significant ($\chi^2$ (1) = 26.36, $p$ < 0.001) as is the difference in retention rate ($\chi^2$ (1) = 3.63, $p$ = 0.057).

The overall course grade average was similar for URM and non-URM students in the ESP Calculus I course (URM 2.86 ± 1.2, non-URM 2.83 ± 1.2); however, in the traditional Calculus I course, URM students scored substantially lower grades than non-URM students (URM 1.72 ± 1.4, non-URM 2.20 ± 1.4). All grades are on a 4-point scale with A = 4 and F = 0; only students who completed the course for a grade are included in the average.

The two classes have different student populations with the ESP class having a somewhat more academically prepared population and, therefore, the differences identified could have resulted from these population differences. To determine whether this was the case, we controlled for academic preparation; the effect of the classes on passing and retention was investigated with logistic regression using ACTM% as a control variable. ACTM% was normalized by subtracting the mean and dividing by the standard deviation. These regressions also used the dichotomous variables Course (Non-ESP = 0, ESP = 1) and Demographics (Non-URM = 0, URM = 1). To investigate whether the ESP course had an additional effect for URM students, interaction terms were added to the regression in the form of the product Course x Demographics. If the ESP course had an additional supportive effect for URM students, then the odds ratio of the interaction would be greater than 1.

First, the dichotomous outcome of passing the class was investigated as shown in **Table 3**. For this model, the interaction term was not significant; ESP and Non-ESP URM students pass each class at the same rate when correcting for ACTM% scores. All students pass the ESP course with twice the odds (odds ratio = 2.3) as the traditional calculus course. Students with higher ACT mathematics scores have an advantage in both courses; a one-standard-deviation increase in ACT scores nearly doubles the odds of passing (odds ratio = 1.86). A likelihood ratio test and Wald test indicate the model presented in **Table 3** is a significant improvement over the null model including only the intercept. However, the Hosmer and Lemeshow (1980) suggests the model is not particularly well fitting. A well-fitting model does not have a significant $p$-value in this test.

A similar model was used to investigate one-year retention; the results are shown in **Table 4**. This model was also a significant improvement over the null model using the Wald test and the likelihood ratio test; however, this model was also well-fitting using the Hosmer and Lemeshow goodness-of-fit test. The ESP course had a dramatic positive effect on the retention of URM students improving the odds of retention by almost a factor of 3 (odds ratio = 2.72). While this result is only significant at the $p$ < 0.10 level, the small sample size suggests it may be more appropriate to examine the size of the effect measured by the odds ratio. Prior preparation was much less important to one-year retention (odds ratio = 1.11), than it was to passing the course (odds ratio = 1.86).

## DISCUSSION AND IMPLICATIONS

The current study examined differences in pass rates and in continuation in college one year post - course for URM and first generation non-URM students in ESP Calculus courses compared to their non-ESP counterparts. Results of analyses showed that ESP URM students succeeded in the Calculus sequence at substantially higher rates than URM students in non-ESP sections in the sequence. In addition, ESP URM and ESP non-URM students succeeded at similar levels in the ESP

**TABLE 3 |** Logistic regression predicting passing calculus I.

| Predictor | $\beta$ | SE $\beta$ | z | p | $e^{\beta}$ (Odds ratio) |
|---|---|---|---|---|---|
| Intercept | 0.51 | 0.03 | 18.9 | <0.001 | 1.67 |
| Course (Non-ESP = 0, ESP = 1) | 0.83 | 0.36 | 2.33 | 0.020 | 2.30 |
| Demographics (Non-URM = 0, URM = 1) | −0.15 | 0.10 | 1.62 | 0.10 | 0.85 |
| ACTM% | 0.62 | 0.03 | 22.7 | <0.001 | 1.86 |
| Course x demographics | 0.08 | 0.46 | 0.18 | 0.856 | 1.09 |
| Overall model evaluation | | | | | |
| Likelihood ratio test | | | $\chi^2$ (4) = 627, $p$ < 0.001 | | |
| Wald's test | | | $F$ (4) = 139, $p$ < 0.001 | | |
| Goodness-of-fit test | | | | | |
| Hosmer and lemeshow | | | $\chi^2$ (8) = 30.53, $p$ < 0.001 | | |

**TABLE 4 |** Logistic regression predicting retention to college one year after calculus I.

| Predictor | $\beta$ | SE $\beta$ | z | p | $e^{\beta}$ (Odds ratio) |
|---|---|---|---|---|---|
| Intercept | 1.85 | 0.04 | 50.5 | <0.001 | 6.35 |
| Course (Non-ESP = 0, ESP = 1) | −0.25 | 0.37 | 0.69 | 0.490 | 0.78 |
| Demographics (Non-URM = 0, URM = 1) | −0.22 | 0.12 | 1.81 | 0.071 | 0.80 |
| ACTM% | 0.11 | 0.03 | 3.15 | 0.001 | 1.11 |
| Course x demographics | 1.00 | 0.55 | 1.81 | 0.070 | 2.72 |
| Overall model evaluation | | | | | |
| Likelihood ratio test | | | $\chi^2$ (4) = 17.92, $p$ = 0.001 | | |
| Wald's test | | | $F$ (4) = 3.54, $p$ = 0.001 | | |
| Goodness-of-fit test | | | | | |
| Hosmer and lemeshow | | | $\chi^2$ (8) = 12.67, $p$ = 0.124 | | |

Calculus sequence of courses. Finally, ESP URM students' one-year retention rates were similar to those of ESP non-URM students, and significantly higher than those of URM students in non-ESP sections of Calculus. These results suggest that ESP is ideally suited for retaining and graduating URM STEM majors, helping to overcome obstacles and barriers in STEM, and increasing diversity, equity, and inclusion in Calculus.

The ESP URM students in this study sample are also LSAMP scholars and are therefore high achievers: to be admitted and remain in the program, scholars should have and maintain a 3.0 GPA. Results from a recent study of 20 LSAMP scholars by Burt et al. (2020) revealed that LSAMP scholars in that alliance also entered their LSAMP program with academic strengths, and that, as in the current study, LSAMP provided necessary formal academic support. The KY-WV LSAMP in this study provides scholars with a sense of belonging and support, while ESP Calculus provides a math learning community in which students experience positive learning and mentoring experiences, encouragement and recognition from peers and teachers that is lacking in non-ESP courses, mitigating the isolation and disconnects that pose significant barriers to success (Fullilove and Treisman, 1990; Bonsangue and Drew, 1995; Moreno et al., 1999). Positive results for first-generation students from this study indicate that the ESP course was also beneficial in retaining and graduating STEM majors from this population. It is unlikely that self-selection into ESP alone could explain these results for both groups of students in ESP, particularly since ESP and non-ESP URM students passed each class at the same rate when correcting for prior preparation.

The data collected for this study formed part of a larger research project guided in part by Tinto's theory of retention (Tinto, 1975; Tinto, 2007), which incorporates both academic and non-academic factors. The project is further informed by Social Cognitive Career theory (SCCT) (Lent et al., 2000). Given the social aspect of the learning community model fostered by ESP combined with the strong positive attitudes and beliefs about the course expressed by the students and the intent of the program to build identification as STEM learners, the SCCT model provides a coherent framework for analyzing the different interacting components observed here. SCCT incorporates Tinto's non-cognitive factors known to be important in retaining students and expands them for use in groups underrepresented in STEM. Tinto's sense of self-efficacy, STEM identity, and belonging have important implications for such groups. The ESP model addressess self-efficacy, STEM identity, and belonging in the social structures that it develops within its cohorts. The communication ideas to peers gives them a chance to develop mathematics in ways that make sense to the students themselves, and the sustained mathematical practices in that environment reinforce factors within the SCCT framework that support STEM learner success and persistence. Interviews conducted during the 2020 pandemic with six current and former recent ESP students indicated that they highly valued the community aspect of ESP and every current scholar reported missing the ESP community during online instruction required as a result of the pandemic.

Results from a recent meta-analysis on the impact of active learning methods on failure rates of over 9,000 URM undergraduate students in STEM courses demonstrated that active learning reduced achievement gaps in examination scores by 33% and gaps in passing rates by 45% (Theobald et al., 2020), but only in STEM classes that implemented high-intensity active learning methods like those employed in this study. Furthermore, while many studies have examined the importance of active learning methods for URM success and retention in STEM, few of them addressed the success of both URM and first-generation students in the context we explored in this study. We believed this was very important, as investigators in the department posited, based on previous research, that first-generation students, along with their URM peers, shared a common background and lack of support structures that may have resulted in a lack of understanding of academic expectations and rigor that support other students (Wingate, 2006). This premise was initially tested and confirmed in related work (Deshler et al., 2016) and continues to be an important aspect of the Emerging Scholars Program at WVU.

As noted above, the active learning methods employed in this and similar studies also provides students with a learning community, so we conclude that active learning alone is not responsible for narrowing gaps. The Treisman paradigm requires a sizeable time commitment from students and educators alike; while this is a potential roadblock, as many URM and first-generation students have jobs and other time commitments that can prevent them from participating in ESP, this time commitment is also partly responsible for creating the cohesive learning community (Lee et al., 2018). Theobald et al. (2020) results highlight the interaction of active learning and community in positive results. They proposed that the heads-and-hearts hypothesis explained the extensive variation in efficacy observed among studies; this hypothesis posits that meaningful reductions in achievement gaps only occur when course designs combine deliberate practice with inclusive teaching, as was the case in this study. Note that the heads-and-heart hypothesis fits well within both Tinto's framework and SCCT and that other recent evidence also demonstrates that learning communities increase the success and retention for first generation and URM STEM students (Solanki et al., 2019; Van Sickle et al., 2020).

Based on ESP student demand, we decided that we would expand ESP to Calculus II during the first semester offering ESP Calculus I in 2009, and for several years we offered ESP Calculus I and II each academic year. With the support of the Mathematics Department prior to the Fall 2013 and continued ESP student demand, we decided to expand ESP to Calculus III and Differential Equations. We have continued to offer ESP for Calculus I and Calculus III in the Fall semesters and Calculus II and Differential Equations in the Spring semesters since 2013. Despite the initial work involved in beginning such a program, the outcomes for the students are compelling while the initial start-up is manageable. To implement a similar program, it may be necessary to lobby administrators and other leadership to allocate instructional time of faculty teams to build a program and to reconfigure physical classroom space. Committing to the process for multiple terms and to giving an ambitious classroom environment the attention it will need can yield outstanding results.

Although it is true that ESP calculus is more time intensive and therefore more costly to implement initially than standard lecture courses, if more students remain enrolled to graduation, the cost could be offset by an increase in tuition dollars resulting from increased retention. More important are the positive impacts including increasing equity in higher education and broadening participation in STEM. The sense of community built within ESP and other learning community focused active learning classroom environments afford students the opportunity to develop mathematics in a culturally responsive (Gay, 2018), meaningful way that resonates with their own experiences. The sustained access to these environments builds agency and identity for students within mathematics and other disciplines, supporting the persistence needed for long-term success in these disciplines. Forty years ago, Treisman's ESP methods (Asera, 2001) showed that URM students could achieve grade distributions equal to or greater than the class as a whole (15 ± 20), while more recent studies show that if his methods are not diluted, the results are equally positive (Lee et al., 2018; Theobald et al., 2020). Therefore, results from this study and others support calls to replace traditional lecture with evidence-based, active-learning course designs across STEM disciplines and that these innovative in instructional strategies can increase equity in higher education.

## Acknowledgement of Constraints

Because these students self-selected into ESP and were better prepared academically, there are limitations to the conclusions that can be drawn from the positive results found in this study; however, similar results have been found by other researchers, suggesting that results from similar ESP-like programs would also be positive (Solanki et al., 2019; Van Sickle et al., 2020). In addition, it is important to study ESP students *because* they are highly motivated, high achieving students, to gain insight into methods for increasing success for other underrepresented students. This study was also conducted at a single institution in a primarily rural state with many first-generation students, thus, whether or not ESP would prove effective for suburban or urban students is not known. As noted, a hurdle in recruiting for this work was the lack of a diverse student body at this institution, and additional qualitative and quantitative research at different institutions with differing demographic compositions is needed to determine if results are similar in other contexts. This work targeted mathematics courses but it should be extended to determine if the results are similar for other STEM courses.

## Permission to Reuse and Copyright



## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the West Virginia University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

All authors contributed to drafting and revising the article. All authors also read and approved the final manuscript. DM and MP implemented the instructional setting, and JS analyzed the data.

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# A Potential Canary in the Coal Mine: A Critical Policy Analysis of the Illinois LSAMP During the COVID-19 Pandemic

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The COVID-19 pandemic has continued to impact every industry and test problem-solving capabilities and innovation across the board; education is no exception. As institutions continue to adapt to the impacts of the current public health crisis, colleges and universities are also navigating federal policy prompted by the pandemic. Literature has shown the positive influence of organizations, such as the Louis Stokes Alliances for Minority Participation (LSAMP), and, we argue that they can take a more active intermediary approach, that of an Organizational Buffer, to best support their students during times of uncertainty. Current research highlights the disconnect between STEM education and policy, as well as how the pandemic is disproportionately impacting communities of color. The pervasiveness of whiteness within educational policy and the negative impacts of unequal distribution of resources on students of color in STEM highlight the need to center race in a theoretical framework and policy. The purpose of this study was to understand the policy and communication responses to the pandemic as they pertained to supporting student success in STEM. Using the Theory of Racialized Organizations, which is a qualitative case study approach that leverages diffractive readings, was implemented to understand whether educational policy and communication responses during this time have or perpetuated inequitable systems. Guided by the research question, in what ways do pandemic policies and communications bolster the success of underrepresented minoritized students (URM) majoring in STEM, our study found four versions of policymaking (i.e., Performative, Picking Winners and Losers, Stay in your Lane, and Time Burden) that emerged and did not support URM STEM students equitably and consistently. Based on these findings, we present implications for institutional responses, LSAMP-alliance support, and future research.

**Keywords: stem education, organizational theory, race, equity, student success, critical policy analysis**

# INTRODUCTION

Since the Louis Stokes Alliances for Minority Participation's (LSAMP) founding in 1991 (Clewell et al., 2006; Baber and Jackson, 2018), there have been numerous focusing events Kingdon (2013) that bring specific issues to the fore of consciousness for policymakers and the public. As a result, these focusing events, when narrowed to particular fields and industries, such as science, technology, engineering, and mathematics (STEM), enable rapid and sweeping changes in how relevant dynamics (e.g., technical skills, accreditation standards, ethical norms, etc.) are taught and performed in both postsecondary education and industry spaces (Henderson et al., 2011; Gruber and Johnson, 2019). For instance, in the 1990s, the rise of Silicon Valley harkened dialogues about the best ways to regulate the emergence of the world wide web Norris and Inglehart (2009) and how to diversify the population of individuals involved in the growing technology space (Twine, 2018). Another example of a focusing event intersecting with STEM emerged after the September 11, 2001 attacks on the World Trade Center in New York. Immigration policies changed, which affected the flow of skilled laborers in STEM professions Kennedy (2019) and had resulting impacts by heightened the need for a greater share of US-born individuals to fill open positions (Orrenius and Zavodny, 2015).

## Purpose

Yet, during these sweeping events and subsequent policy actions, there are rarely efforts to take stock of the evolving policy environment and analyze dimensions embedded in the policymaking process as a crisis unfolds, especially within the STEM education literature. Consequently, the purpose of this paper is to understand the focusing event of the COVID-19 pandemic and its resulting policies and how they intersected with enablers of student success in STEM education through the lens of institutions affiliated with the Illinois LSAMP (IL-LSAMP) (see **Table 1**). Birkland (1998) describes focusing events as occurrences that are:

sudden; relatively uncommon; can be reasonably defined as harmful or revealing the possibility of potentially more significant future harms; has harms that are concentrated in a particular geographical area or community of interest; and that is known to policymakers and the public simultaneously. (p. 55).

The COVID-19 pandemic fits such a description and provides the departure point for our study. The concept of focusing events flows from Kingdon's (2013) assessment of the policymaking process and agenda-setting in particular. In Kingdon's (2013) articulation, focusing events galvanize the interest and support of a coalition of policymakers who are newly coupled together to move the policymaking process along in a way that addresses both new and pre-existing issues. As the next section will bear out, it is not typical to study STEM education from the policymaking process's vantage point. However, STEM education is impacted both directly and indirectly by the policymaking process at institutional, local, state, and federal levels (Ong et al., 2011). Consequently, the ongoing nature of the COVID-19 pandemic and the series of "stimulus" bills passed by Congress beginning in March 2020 frame a unique opportunity to examine policy formation and implementation occurring together over a relatively brief period (Hillman et al., 2015).

Furthermore, the documented racial disparities across health, economics, and education that have only been worsened by the pandemic prompt us to foreground an analytical strategy that heightens our ability to locate racial dynamics in the policy process and within organizations (Harper, 2010; Young and Diem, 2018; Ray, 2019). Finally, it is essential to note the specific impetus for this study, which was as an Alliance wide conference call the research team members participated in during May of 2020. We listened along, feeling helpless as our colleagues grappled with how to carry on the Alliance's work while addressing their other work responsibilities and surviving a pandemic. While there was a collective sense of relief as the summer approached, there was also a sense of dread as many of the activities planned for the summer across the Alliance were either being canceled or postponed.

Knowing the already limited capacities and resources for the people who make the Alliance what it is and the pandemic-induced struggles of its member institutions, we quickly turned our attention to the various policies designed and implemented to support students' success and institutions as a whole through the pandemic. We contend that the Alliance is a uniquely positioned National Science Foundation. (NSF) program because it has a governing board made up of all its constituent institutions' chancellor or president. In a pandemic, where the STEM ecosystem's prospects for equitable success were most vulnerable, we hoped that the Alliance could rally the collective insights and leadership of all of its essential elements to navigate through the situation. Only time will tell the full extent of the early parts of the pandemic on the Alliance and the prospect of its underrepresented minoritized[1] (URM) STEM students, but what felt like an exercise that could be addressed more immediately was the extent to which the policies and communications amid the pandemic even sought to address student success in STEM with an eye towards equity. By equity focus, we mean devoting the requisite level of resources at all levels of the institution to ensure minoritized groups have opportunities and support to realize their educational outcomes and exhibit the fullest extent of their agency and talents (McNair et al., 2019; Rall et al., 2020).

## General Approach and Research Question

We leverage a case study approach that utilizes a policy analysis tool of diffractive readings Ulmer (2016) to explore educational policy and communication responses to the pandemic. In particular, we center the role of organizations in legitimizing or disrupting systems of inequity around race, regardless of the

[1]We use the term "minoritized" rather than minority in concurrence with Harper's (2010) call to bring attention to the interaction of oppressive forces within organizations that render minority status on certain groups due to their incongruence with the prevailing norms of the space. This term also acknowledges that people who are considered "minorities" or "underrepresented" are not always numerically in the minority, as was the case with this project.

**TABLE 1** | IL-LSAMP institution characteristics.

| Institution name | Governance/control | Overall completion rate for URM STEM students (%) | Number of STEM programs | CARES Act emergency funding (minimum allocation for student aid) |
|---|---|---|---|---|
| Chicago State University | 4-year public | 3.40 | 5 | $1,086,007 |
| DePaul University | 4-year private | 2.96 | 17 | $7,186,610 |
| Governors State University | 4-year public | 4.77 | 5 | $1,851,301 |
| Illinois Institute of Technology | 4-year private | 16.17 | 28 | $1,865,000 |
| Malcolm X College | 2-year public | 15.42 | 3 | $2,459,879 |
| Morton College | 2-year public | 19.27 | 5 | $1,266,322 |
| Northeastern Illinois University | 4-year public | 5.44 | 11 | $3,035,452 |
| Prairie State College | 4-year public | 9.96 | 5 | $1,261,894 |
| Southern Illinois University, Edwardsville | 4-year public | 1.84 | 13 | $4,893,197 |
| St. Augustine College | 4-year private | 3.40 | 1 | $748, 491 |
| University of Illinois, Chicago | 4-year public | 8.32 | 21 | $14,937,295 |
| University of Illinois, Springfield | 4-year public | 3.97 | 7 | $865,944 |

*Note:*
**We take URM to represent: American Indian and Alaska Native, Black or African American, Hispanic/Latino, and Native Hawaiian or other Pacific Islander.*
**We take STEM to be programs of study in engineering and engineering technology, the biological and biomedical sciences, computer and information sciences, health professions, mathematics and statistics, and physical and life sciences.*
**We take undergraduate to mean associates and bachelor's degrees where appropriate.*

racial equity values espoused in official pandemic-related communication and documentation. The question that oriented our exploration was: In what ways do pandemic policies and communications bolster the success of underrepresented minoritized students (URM) majoring in STEM?

## Imbalance in the Ecosystem: Disrupting Progress in STEM Education

Journalists, academics, policymakers, and the broader public are in widescale agreement that no industry has been left undisturbed by the COVID-19 pandemic (Kushner Gadarian et al., 2020). Yet, many argue that the education sector has been hit particularly hard because of the shift to wide-scale remote learning (Collier et al., 2021). In addition, at the postsecondary education level, the disparate ways institutions have chosen to respond to the pandemic has led to an array of approaches that all have nuanced impacts on students that we are only beginning to understand (e.g., Collier et al., 2020; Marsicano et al., 2020; Whatley and Castiello-Gutiérrez, 2021); further, higher education budgets are often the first victims of tightening state budgets. Importantly, researchers are making initial cases that remote learning during the pandemic has an exaggerated negative effect on STEM instruction and STEM students' performance (McCormick, 2021). This emerging reality also dovetails with the disruption of the momentum in the last 10 years to shift STEM pedagogy to be more participatory and collaborative (Henderson et al., 2011; Dewsbury, 2020). These dynamics and others have led educational leaders to opine about the extent to which the pandemic is only furthering pre-existing worries about equity and persistence in STEM for URM student populations (Goodwin & Mitchneck, 2020; Woolston, 2020). Bolstering the STEM education enterprise will ensure the entire system's longevity and viability; no component of the policy ecosystem can be ignored.

## Torques and Tensions: The Political Dynamics of Science and Policy

These realities set the context for policymakers and administrators' intentional actions to address the emergent and underlying issues through policy. Although the Biden-Harris Administration The White House (2021) has made early efforts to be more deliberate about connecting science and policymaking, that is a relatively recent development. Since the Cold War days, there has been a tenuous relationship between policy and science (Gruber and Johnson, 2019). The precarious relationship between the entities and concepts is rooted in the partisan realities that policymakers must navigate to stay in elected office (Bolsen and Druckman, 2018). These tensions differ from the occasionally disengaged posture individuals in the STEM community embrace, which is rooted in an effort to seem above or disconnected from the political fray (Nature Editorial Board, 2020). The impact of this bumpy relationship spreads into the realities of its constituent parts, such as STEM education and the policies that directly and indirectly impact student success in postsecondary education. Therefore, our literature review seeks to further situate our exploration on this topic alongside existing knowledge of policy, STEM education, whiteness, and organizational responses.

# LITERATURE REVIEW: CREATING "THICK UNDERSTANDINGS"

This literature review aims to build for ourselves and the reader what Murris and Bozalek (2019) describe as "thick understandings" of the area of exploration. Thick understandings are created by "re-turning to the past [literature on the topic]" with an intent to frame points of engagement with existing understandings of life rather than to review, critique, and set aside (Murris and Bozalek, 2019,

p. 1512). Consequently, our exploration begins first by examining the disconnect between STEM education research and policy. We contend that strengthening the connection between these two domains is beneficial for STEM education research and practice. Next, since research has shown the pandemic has disproportionately impacted communities of color (DeMatthews et al., 2020; Fortuna et al., 2020), we highlight the pervasiveness of whiteness within educational policy. Making this connection felt especially prudent to crafting a thick understanding of our topic because of the harmful impacts of unequal distribution of resources on students of color within STEM—spurring the need to center race in policy language. Lastly, we focus on LSAMP organizations and the intermediary functions (Honig, 2004) they can take advantage of in times of uncertainty to best serve their constituents by examining the current roles research has asserted they play. Together, these points scaffold us toward the understanding that STEM education and policy likely become intertwined within organizations, like postsecondary institutions and arguably LSAMP, in ways that are far more complex than typically acknowledged in the literature.

## Gap Analysis: Public Policy and STEM Education

STEM education research, similar to science research more broadly, is often disjointed from the policy context it is situated within (Kezar and Holcombe, 2019; Nature Editorial Board, 2020). The disconnect is potentially harmful to students and institutions for reasons including securing and maintaining funding (Fischhoff and Scheufele, 2014), ensuring stakeholder priorities are aligned, and the need for current and future research (The National Academies of Science Engineering Medicine, 2017). NSF contributes to a significant portion of funding that supports STEM education. Although contested (Roberts, 2009), the reasoning for this continued support of STEM education is based on the perception that the U.S. STEM workforce will decline significantly in the future, putting the national standing in jeopardy and there needs to be a concentrated effort to support and produce STEM graduates (Mansfield et al., 2014; Doerschuk et al., 2016; Gruber and Johnson, 2019; Lord et al., 2019). Therefore, STEM education research that does not consider the policy context potentially puts the STEM education enterprise at risk, financially and institutionally, if not continually positioning the enterprise as a public asset to the nation. Accordingly, an awareness of the narratives and current events taking place that deem STEM education as essential or not is vital as is locating it within the agenda-setting Kingdon (2013) and policymaking process (Hillman et al., 2015).

## Message Diffusion: Policy Communication

In addition to federal funding and policies that impact STEM education and research, the application and communication of policies at an institutional level is a distinct but related consideration (Ness, 2010; Faehnrich and Ruser, 2019). Anderson (2012) investigated how policy, specifically test-based accountability policies, influences practice at the school level. Anderson (2012) concluded that policymakers must consider how educators make sense of the new or adjusted policies in order to avoid the educator's feeling unnecesairly constrained in their instructional methods. This is corroborated in additional studies of faculty and staff members involved in STEM organizational change (Gehrke and Kezar, 2017; Bensimon et al., 2019; Park et al., 2020). However, these studies do not foreground a concern for public policymaking. In the public policy domain, Spillane and Callahan (2000) highlighted a revealing case of a district change effort around STEM within primary and secondary education. They found that when district policymakers do not understand the vision or purpose of ideas that can reform or better support STEM education (i.e., science standards), it is difficult for the implementation to align with the original intent (Spillane and Callahan, 2000).

## Forced Evolution: Re-Evaluating Policy Priorities

It is essential to acknowledge the varied support and resources different populations of STEM students need to advocate for policy that addresses these needs (Harper, 2010; McGee, 2016; Ong et al., 2011; Garibay, 2018; Ong et al., 2018). If STEM education researchers continue to be detached from the policy process, then there is concern that change may remain limited to individuals and networks' capacities and inputs (Gehrke and Kezar, 2017; Hill, 2020). In contrast, much has been gained in the areas of college access (Harper et al., 2009; Hillman, 2016; González Canché, 2018), institutional funding Jones et al. (2017), Gándara (2020), and improving campus climates (Glasener et al., 2019; LePeau et al., 2019) when their intersection with policies are foregrounded as an issue of interest for researchers. Therefore, it is crucial for STEM education research to be more aware of, and engaged with, policymaking and policy implementation to better support and retain students.

## Pre-Determined Realities: Educational Policy and the Construct of Whiteness

In considering how to best support URM STEM students during a pandemic, we turn next to how students continue to navigate an inequitable system and unequal support structures that are in place. Research has shown the negative impact and unintended consequences that occur when resources are distributed inequitably within education particularly for racially and ethnically minoritized students (Harper, 2010; Ong et al., 2011; Burt et al., 2020). Specifically, when resources are not allocated fairly and equitably this enables the following factors to persist which contributes to URM STEM students being less likely to be retained and complete their degrees: graduating from low-resourced high schools (Means et al., 2018; Glennie et al., 2019; Morales-Doyle et al., 2019), experiencing racial stereotypes and racism in college classrooms (McGee, 2016; McGee, 2018); being the only or one of a few students from one's racial group in STEM courses (Ireland et al., 2018; Ong et al., 2018); having minimal or no exposure to professors of color in STEM majors (Hurtado et al., 2011; McCoy et al., 2017; Park et al., 2020); ineffective teaching and mentoring (Bensimon et al., 2019; Haynes and Patton, 2019; Dewsbury, 2020); and culturally unresponsive or decontextualized curricula (Bullock, 2017; Wolfmeyer et al., 2017; Madkins and Nasir, 2019). These racialized realities from the vantage point of STEM are often not considered in educational policy which further supports the inequitable distribution to persist.

On the other hand, educational policy research is often presented as neutral and intended to be fair in its application, regardless of racialized realities (Diem et al., 2014; Tichavakunda, 2020). Research continues to indicate that this presentation is not realistic and that policy cannot be applied in a one size fits all approach due to the complexity and the persistence of intersecting oppressive systems and ideologies in the United States (e.g., systemic racism, sexism, ableism, heteronormativity, etc.) (Gillborn, 2005; Diem et al., 2014; Johnson and Howley, 2015; Harris and Patton, 2018). The cause of this neutrality in policy has been connected to the pervasiveness of whiteness within education (Gillborn, 2005; Diem et al., 2014). Whiteness is a social construct that functions to reinscribe white supremacy and the subordination of non-white races, across different contexts, within a society (Owen, 2007).

Research in other areas of higher education that center on whiteness have shown the pernicious effects for multiple stakeholders which include a lower sense of safety on campus, less sense of belonging, and decreased academic performance (Cabrera, 2014; LePeau et al., 2016; Stewart and Nicolazzo, 2018; Haynes and Patton, 2019). Extended into the policy realm, education scholars have begun to unearth how whiteness exists in various ways within the education system and policy (e.g., segregation, testing, funding, unequal resources, etc.) Gillborn (2005), Harper et al. (2009) and continues to exist within colorblind approaches and language (Harper, 2012; Tichavakunda, 2020). Therefore, any exploration into educational policy must be explicitly attuned to the dynamics of whiteness and the sites where those dynamics play out.

### A New Frontier?: LSAMP During Times of Crisis

The LSAMP program began to better support the retention and completion of URM STEM students and encourage them to pursue STEM-related roles after receiving their baccalaureate degree (Clewell et al., 2006; Cox et al., 2012; Baber and Jackson, 2018). Concerns for the longevity of the United States STEM workforce, the projected decline of United States STEM graduates, and other fears (e.g., drop in productivity, international competitiveness) led the NSF (n.d.) to prioritize efforts to support the retention of URM students, who are traditionally underrepresented, in STEM through initiatives like LSAMP for over 2 decades. LSAMP includes multi-institutional collaboration through alliances that provide students with academic support, mentorship, research opportunities, and in some cases, funding. Programming through LSAMP is supported through grant funding. Research has shown that LSAMP are beneficial and effective for URM STEM students when the programming does not have to navigate policy or legal restraints (e.g., Hopwood Decision) (Graham et al., 2002).

Although the strengths and weaknesses of LSAMP vary by state and is dependent on the campuses they are located on (Baber and Jackson, 2018), the programming is considered beneficial for the URM STEM students as well as the institutions involved (Graham et al., 2002; Cox et al., 2012; King et al., 2016; Burt et al., 2020). However, these studies of LSAMP may not be fully reflective of programming during a time of crisis or policy influences on outcomes. Nevertheless, due to the intimate relationship this programming has with URM STEM students, it can anticipate the needs of these students if a crisis does occur and address their needs in a timely and efficient manner through multiple levels of intervention. The levels of potential intervention include peer supports (Ong et al., 2018), faculty mentoring (Gehrke and Kezar, 2017; McCoy et al., 2017), staff advising (Bensimon et al., 2019), and institutional leadership (Kezar, 2011). This reality invokes the need to situate better the role of policy Hillman et al. (2015) and strategic communication (Faehnrich and Ruser, 2019), which can serve as external mechanisms to spur organizational change to support students (Kezar and Holcombe, 2019).

### In/Conclusion

The impact of the COVID-19 pandemic will continue to become more well-defined as time goes on. As the literature has depicted in STEM education, pre-existing disparities and dynamics will be exacerbated by the pandemic. Therefore, institutions and policymakers need to be aware of the array of potential realities to be proactive in their approaches to mediate inequities. Although there is more research needed on organizational change and STEM education and policy in a crisis, there are resources and programming that currently exist that can be used to better support students. LSAMP programming, which is already funded and in place, can play a more active intermediary role Honig (2004) between their campus community and policy that is affecting their institutions. In addition to reframing how to use programming to better support URM STEM students, there is a need for STEM education to understand how it is situated within policy and how to strengthen that relationship (e.g., creation, implementation, understanding) in order to be prepared and equipped in a time of crisis and beyond (Hillman et al., 2015).

## THEORETICAL FRAMEWORK

As our review of the literature highlights, the intersection of public policy, the experiences of racially minoritized individuals, and STEM education is primed for an investigation that can yield novel insights. These domains' confluence often manifests in organizations such as postsecondary education institutions or a collection of organizations such as the LSAMP. As entities such as these continue to grapple with how to address persistent challenges related to the access and success of URMs in STEM amid and following the pandemic, the prevailing question becomes how to carry out their practices and policies in ways that do not reify deficit-laden descriptions of students of color Harper (2010), McGee (2016) and constrain their educational potential (Garibay, 2018). The weight of this lofty effort is compounded by the dearth of research at this intersection, which also means that few theories can be intentionally leveraged to frame these organizational dynamics. Therefore, we turn to the discipline of sociology and the theory of racialized organizations Ray (2019) to highlight relevant dimensions of interest for our diffractive policy analysis (Ulmer, 2016).

## Ray's Theory of Racialized Organizations

Ray (2019) developed the theory of racialized organizations because of their simultaneous critique that race issues are often omitted from organizational analysis and race theory is often devoid of organizations as a site of analysis. Said another way, when STEM education scholars are concerned with organizations, they tend to privilege the investigation of other issues (e.g., graduation, technical skill development, etc.) over racialized concerns (Porter et al., 2006; Gehrke and Kezar, 2017; Reinholz and Apkarian, 2018). Conversely, as numerous studies call out (McGee, 2016; Bullock, 2017; Ong et al., 2018), STEM education research tends to shy away from naming issues of race as an explanatory mechanism in their analysis.

## Definitionand Three Core Tenets

> Ray (2019) defines racialized organizations as: meso-level social structures that limit the personal agency and collective efficacy of subordinate racial groups while magnifying the dominant racial group's agency. The ability to act upon the world, to create, to learn, to express emotion,–indeed, one's full humanity is constrained (or enabled) by racialized organizations. (p. 36).

Ray (2019) suggests that organizations mediate human agency on a spectrum of three core components: 1) the unequal distribution of resources, 2) the credentialing of Whiteness, and 3) racialized decoupling. We briefly overview each of the components of the theory of racialized organizations and revisit them in the findings section to pair with our data.

### Unequal Distribution of Resources

This tenet refers to the historical and contemporary manifestation of segregation within organizations that helps to "maintain racial boundaries, channel resources, and help direct collective action" (Ray, 2019).

### Credentialing of Whiteness

This tenet builds on the assertion of Whiteness as a form of property interest (Harris, 1993). Ray (2019) argues that Whiteness has become the de facto mechanism for allocating resources within organizations and reinforces work hierarchies. Thus, creating policies to address STEM education remains mindful of the cumulative advantages some students may have over others because of how organizations typically enable advantages to be accrued based on their proximity to Whiteness.

### Racialized Decoupling

Finally, Ray (2019) alerts us to the concept of racialized decoupling in organizations. Racialized decoupling is the process of disentangling "formal commitments to equity, access, and inclusion from policies and practices that reinforce, or at least do not challenge, existing racial hierarchies" (p. 42). This tenet is particularly relevant to our analysis because it identifies practices that embolden organizations to perpetuate structures and the unequal distribution of resources while doing very little to disrupt or transform entrenched racial dynamics. Taken together then, the theory of racialized organizations is appropriate framing for our study because it focuses on how Whiteness operates within organizations in ways that are hard to detect. Especially given our effort to map the intersection of public policy on STEM education with a racialized focus, these tenets are especially germane. Also, it is important to us that our analysis be concerned with ultimately making policy and practice recommendations focused on addressing inequity dimensions. Lastly, as the next section will detail, the theory is critical to crafting and operationalizing our research design around diffractive readings and critical policy analysis (Ulmer, 2016).

# RESEARCH DESIGN

Our overall approach was driven by critical policy analysis (CPA) Diem et al. (2014), Apple (2019) and operationalized through the specific method of diffractive reading. In response to this paradigm of policy studies, critical policy analysis has emerged as an approach that is more imaginative and moldable to different purposes, especially in education research (Ulmer, 2016; Young and Diem, 2018) (Ulmer, 2016; Young and Diem, 2018). This process is illustrated in **Figure 1** and described below.

## Critical Policy Analysis

Critical policy analysis in education research tends to deal with one or more of five fundamental concerns. These include: 1) the gap between "policy rhetoric and practiced reality;" 2) policy development; 3) "distribution of power, resources, and knowledge and the creation of "winners" and "losers" ;" 4) social stratification; and 5) engagement and resistance of "non-dominant" groups in policies (Diem et al., 2014, p. 1072). Further, critical policy analysis projects tend to seek to capture the full complexity of policy processes (Diem et al., 2014; Young and Diem, 2018). This includes contextualizing the differential impact of policies, the diverse actors connected to the policy, and how policies evolve. Our study spans the federal, state, local, and institutional domains to understand how pandemic policies converge on institutions to compel differential impacts between URM and non-URM STEM students.

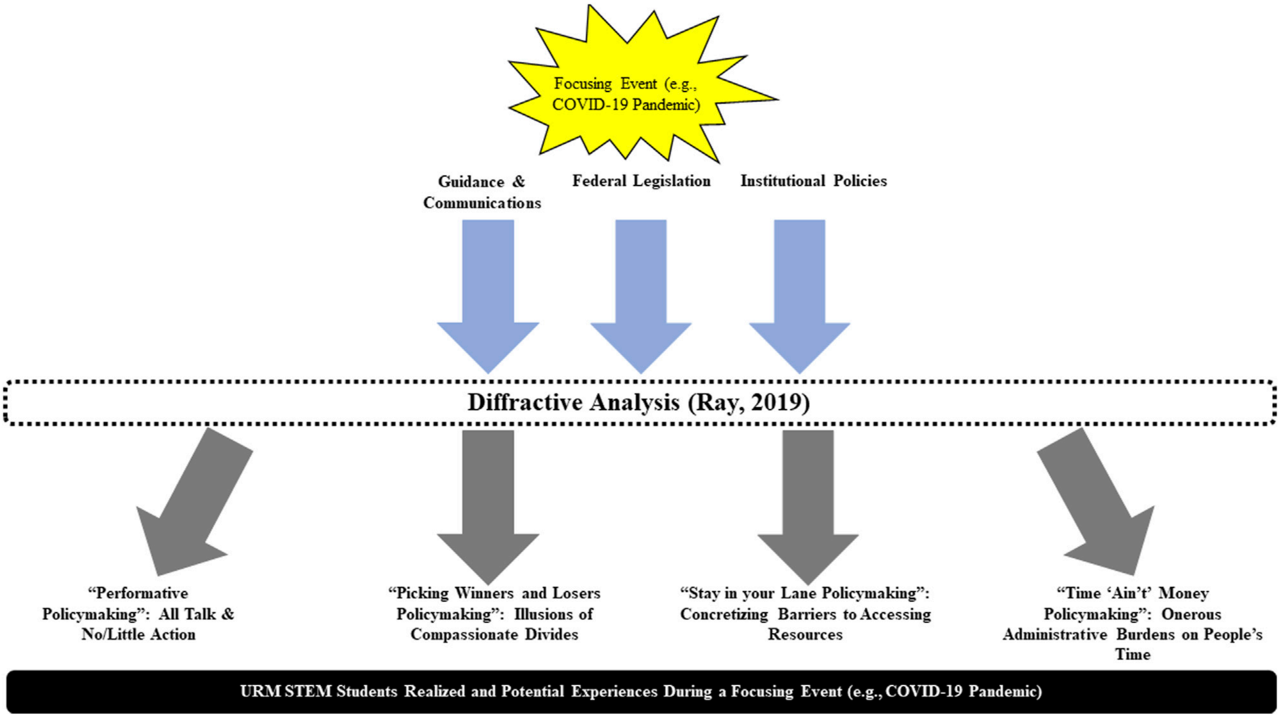


**FIGURE 1 |** Diagram of a Diffractive Reading of COVID-19 Policies and Communication Impact on URM STEM Students.

## Diffractive Analysis

The specific method of critical policy analysis we employed is diffraction analysis. The concept of diffraction is borrowed from the physical sciences and used to describe the process of waves interacting with an obstacle (i.e., light waves diffracting through a prism to showcase different hues). Diffractive readings of policy then are primarily focused on differences and, most importantly, the effect of differences in the data produced through the analysis (Ulmer, 2016; Murris and Bozalek, 2019). Accordingly, the emergence of diffraction as a form of qualitative analysis posits that a more realistic and nuanced rendering of a phenomenon is possible when the researcher embraces a topic's complexity rather than seeking to reduce it to an essence (Ulmer, 2016; Murris and Bozalek, 2019). An increasing number of education studies have adopted this approach in various ways (Taguchi, 2012; Davies, 2014; Bodén, 2015).

## Positionality

Murris and Bozalek (2019) assert that it is also vital to deconstruct "power-producing binaries. . .by being aware of who, or what, is included and excluded through the diffraction apparatus" (p. 1507). The data sources section below tackles the what, but in this section, we want to briefly overview who we are to meld "values and facts. . . together as part of one brew" (Murris and Bozalek, 2019, p. 1509).

The research team is made up of two people that identify as cis-heterosexual Black men (Authors 1 and 4) and two cis-heterosexual women, one who identifies as White (Author 2) and the other as Hispanic (Authors 3). The team collectively has a range of experiences with STEM education, including one current STEM undergraduate student (Author 3) and another team member who has baccalaureate and graduate degrees in engineering (Author 4). Likewise, the team's experiences in policy range from previous work on Capitol Hill (Author 4) and in a Governor's office (Author 2) to no formal experience in policy (Authors 1 and 3). Our positioning relative to the IL-LSAMP is also important to note as the entirety of the team contributes to various research projects that advance our understanding of the Alliance from different vantage points ranging from research volunteer to co-principal investigator.

The teams' collective and individual interest in these topics is shaped at a high level by an overarching concern for educational inequities, a belief in the importance of STEM as a mechanism for the uplift in minoritized communities, and a commitment to institutional change spurred by policy development and organizational transformation rooted in anti-deficit thinking (Harper, 2010). Consequently, we acknowledge and make explicit that our insights, identities, and experiences predated our engagement in this project and bind our analysis in a way that makes addressing inequities and student success the focal point.

## Data Sources

We follow Ulmer's (2016) outline for enacting diffraction as a critical policy analysis method and highlight the full range of texts used in our study over the period of March 2020 to October 2020. **Table 1** includes relevant characteristics for each of the institutions in the IL-LSAMP, which constitute the initial focus of our inquiry. From these institutions, our policy document ecosystem included; (a) The postsecondary education provisions of legislation passed by the US Congress to address and mitigate the effects of COVID-19; (b) policy and guidance statements from federal agencies related to allowable uses and intents of COVID-19-related funding; (c) policy statements from the Illinois state government and its agencies related to COVID-19 regulations and resources; and (d) Institution and STEM department-specific COVID-19 policies at the 12 IL-LSAMP institutions (Chicago State University, n. d.)—including any downloadable messages to students and the broader university community.

In total, we collected 120 documents that formed the data set for this study. These documents were saved as PDF files and uploaded to Dedoose (qualitative data management tool) for data analysis. **Table 2** provides representative examples of the types of documents and excerpts in our data set.

## Data Analysis

Our central research question speaks to the ways pandemic policies and communications bolster the success of underrepresented minoritized students (URMs) majoring in STEM.

However, we noted both anecdotally and through the data collection process that few, if any, documents specifically addressed the success of students majoring in STEM. This also meant that it would be even less likely to find policies and communication during the early stages of the pandemic that addressed the intersection of URMs in STEM specifically.

Consequently, a diffractive analysis allows us to "read with the data" using theory (Ulmer, 2016; Murris and Bozalek, 2019), meaning we were able to focus on what was revealed in our data sources in light of how the data sources interacted with Ray's (2019) theory of racialized organizations and our multi-pronged diffractive analysis. Relying on a team approach to diffractive analysis allowed us to refract the policy documents through a racialized lens informed by our individual and collective interpretations.

## Analysis Procedures

To enact this process, we first divided the 120 documents among the three team members and conducted a high-level overview of the policy documents in the context of Ray's (2019) theory to developed thematic codes. We then conducted multiple rounds of deductive coding—which produced 170 unique excerpts of text and participated in individual and group memoing. These steps yielded a total of 16 memos, which identify findings most responsive to our research question. Specifically, our dialogue led to identifying four considerations that illuminate patterns or potential patterns of racialized realities in how policies and communication strategies come together within organizations around student success in STEM.

# FINDINGS—DIFFRACTIVE READINGS: THE POTENTIALITIES OF POLICYMAKING FOR URM STEM STUDENT SUCCESS

Our findings capture four main themes: (1) performative policymaking by institutions; (2) funding segregation; (3) bolstering existing barriers to resources; and (4) insufficient time considerations. To present our collective analysis, we model the process of diffractive readings in the sections that follow. The format we utilize includes presenting an excerpt of Ray's (2019) theory of racialized organization and then an articulation of how various data sources entangle and disentangle with the excerpt to shed light on our orienting research question. Our overarching assertion is that the confluence of policymaking and communication amid a pandemic illuminates the potential role of organizations like LSAMP to leverage their existing positioning to facilitate enhanced URM STEM students' outcomes during focusing events.

## "Performative Policymaking": All Talk and No/Little Action

> Racialized organizations often decouple formal commitments to equity, access, and inclusion from policies and practices that reinforce, or at least do not challenge, existing racial hierarchies. (Ray, 2019, p. 42).

The all talk and no/little action finding exposes how organizations formally address inequality and racial disparity but, do not provide an action plan moving forward to target these inequities. This theme falls into Ray's (2019) description of racialized decoupling, as organizations often present themselves as "neutral" or "progressive" for initially highlighting the existence of racial disparities but do not adequately deal with the injustice taking place. This theme emerged from data analysis in several ways, including through state-level communication and higher education institutional response to the campus community.

For instance, the Governor's office in the State of Illinois began issuing proclamations focusing on the COVID-19 pandemic on March 12, 2020. On May 29, 2020, the Governor acknowledged that the COVID-19 virus had a disproportionate impact on the Hispanic and Black community, "…COVID-19 has claimed the lives of and continues to impact the health of Black and Hispanic Illinoisans at a disproportionately high rate-magnifying significant health disparities and inequities…". This proclamation, as well as following proclamations, continued to recognize the racial disparity in the number of COVID-19 cases but did not provide an action plan on how to minimize the spread in these communities and better support them during the pandemic. Given the location of some of the IL-LSAMP institutions in locations with disproportionately high COVID-19 positivity rates, this state-level inaction potentially creates additional burdens for students, faculty, and staff that reside in the surrounding geographic areas.

Yet, this entanglement of acknowledging the underlying pandemic-related issues, but not conveying specified plans, was present in various institutional responses (i.e., email communication) to students. One example includes a university moving to a pass-fail grading method in response to the hardship the pandemic has created for students. However, the university did not articulate how this new grading method would be rolled out, how students would be supported equitably in the

**TABLE 2 |** Overview of data sources and representative examples.

| Policy actor | Example data sources | Example excerpt relevant to student success |
|---|---|---|
| Federal Government<br>Presidential Actions (n = 1)<br>Congressional Legislation (n = 6) | Coronavirus Aid, Relief, and Economic Security Act'' or the ''CARES Act | SEC. 18004. (a) IN GENERAL—The Secretary shall allocate funding under this section as follows: (1) 90 percent to each institution of higher education to prevent, prepare for, and respond to coronavirus, by apportioning it— (A) 75 percent according to the relative share of full-time equivalent enrollment of Federal Pell Grant recipients who are not exclusively enrolled in distance education courses prior to the coronavirus emergency; and (B) 25 percent according to the relative share of fulltime equivalent enrollment of students who were not Federal Pell Grant recipients who are not exclusively enrolled in distance education courses prior to the coronavirus emergency |
| Federal Agencies<br>• Department of Defense (n = 1)<br>• Department of Education (n = 14)<br>• Department of Energy (n = 1)<br>• National Institutes for Health (n = 2)<br>• National Science Foundation (n = 6) | NSF Implementation of OMB Memorandum M-20–17, entitled, "Administrative Relief for Recipients and Applicants of Federal Financial Assistance Directly Impacted by the Novel Coronavirus (COVID-19) due to Loss of Operations" dated March 19, 2020 | "As we face new and unique challenges in confronting the COVID-19 epidemic, NSF is prioritizing the health and safety of the research community. NSF understands the effects this challenge will have on NSF-funded research and facilities, and we are committed to providing the greatest flexibilities to support your health and safety as well as your work. NSF is continually updating guidance and our online resources to keep you informed |
| Illinois Government<br>Department of Health (n = 1)<br>Illinois State Board of Education (n = 1)<br>Governor's Office (n = 21) | Illinois CARES Act Fund Distribution for Higher Education Institutions | Illinois higher education institutions will receive $429.7 million in funding under the CARES Act to help address the financial impact of COVID-19. Half of this funding, $214.9 million, has been released to help provide assistance to students. The remaining funding goes to individual schools to cover refunds and loses related to the COVID-19 response. This is part of the $13.953 billion provided for higher education under the CARES Act, section 18,004 |
| IL-LSAMP Institutions<br>• Chicago State University (n = 8)<br>• DePaul University (n = 15)<br>• Governors State University (n = 1)<br>• Illinois Institute of Technology (n = 8)<br>• Malcom X College (n = 6)<br>• Morton College (n = 11)<br>• Northeastern Illinois University (n = 6)<br>• Prairie State College (n = 1)<br>• Saint Augustine College (n = 0)<br>• Southern Illinois University, Edwardsville (n = 4)<br>• University of Illinois, Chicago (n = 4)<br>• University of Illinois, Springfield (n = 1) | March 21, 2020: REMOTE/ONLINE CREDIT CLASSES BEGIN THIS WEEK — THE WEEK OF MARCH 23RD (Malcolm X College) | Dear Students,<br>As challenging as this week has been, we have witnessed tremendous resilience and dedication by you and all your fellow students. City Colleges faculty and staff have been working over the past week to be ready to resume courses this Monday, March 23. All credit courses except those listed here. . .] will resume with remote instruction. The entire City Colleges team is committed to your success, and we want to ensure that you are ready to complete your courses this term Please read this email carefully so you know what to expect |

transition, or options for students who needed letter grades (i.e., to increase their GPA score, applications). Another institution addressed safety concerns of their campus community, "Please be safe, while acknowledging that safety at times is a privilege not shared by all; be kind to others while standing up for truth and justice, and most of all be kind to yourselves." Although the university may appear to be progressive in acknowledging the racialized context of safety, they fail to provide resources for the students to be safe on and off-campus.

When it comes to the additional uncertainty URM students majoring in STEM might be navigating, these mixed messages might heighten tensions and concerns around staying on task and achieving the requisite technical skills, in a safe environment that will be expected of them to enter the labor force (Garibay, 2018; Lord et al., 2019). Diffracting these data through the theory illuminates how organizations, even with the best of intent, do not always adequately address the impact of their decisions or structures in place. When organizations acknowledge racial disparity but do not actively work to dismantle the oppressive structures that keep inequity in place, they fail to support those in their network in a meaningful way. Accordingly, this brings into view the role an Alliance might have played in advocating for follow-through and accountability on behalf of the communities and students who were being acknowledged, but potentially not supported, in accessible ways. In particular, Alliance leadership could consider ways to stay up to date with the messaging and actions each member institution is relaying in order to understand the context STEM students are navigating. A suggestion moving forward is not only to stay up to date on changes and communications at the institutional, state, and federal level, but also to follow up with the individual institutions who may not be providing inclusive and equitable support systems. This follow-up could be sharing research and best practices, concerns from students and staff, and ultimately call attention to the work that needs to be done.

## "Picking Winners and Losers Policymaking": Illusions of Compassionate Divides

> Within organizations, segregation or incorporation into the lower tires of organizational hierarchies diminishes one's ability to influence organizational procedures and the larger institutional environment (Ray, 2019, p. 36).

The Compassionate Divides dynamic focuses on how through educational policy, whether intentionally or not, separation of populations occurs within higher education. This separation can often limit peoples' access to resources based on their segregated group, create or maintain racial boundaries, and impose limitations on individual and collective influence on organizational change. This finding falls into Ray's (2019) description of segregation as an agency constraint of those in organizations. The funding available to higher education institutions through the CARES Act is based on enrollment classifications and numbers of students (i.e., full-time students, part-time students, Pell Grant-eligible students). This funding formula prioritizes full-time students over part-time, which in turn allocates more funding to schools with higher numbers of full-time students and less to those with higher part-time students. The parameters for allocation of funding through the CARES Act are critical to recognize because there are STEM students who are full-time, part-time, or Pell Grant recipients. Funding distribution based on rigid student classifications, like those identified previously, can disproportionately harm individuals in the segregated tiers that receive less money without sufficient consideration of actual financial need.

Funding segregation also occurred through federal agencies, like the National Institutes of Health (NIH), through the additional funding eligibility criteria: only those projects able to refocus on COVID-19 were eligible. In the absence of a complementary offer of technical assistance for such a task, or broader and more generous eligibility criteria, there remains a risk of this agency constraint limiting access to resources and limiting participation for vulnerable students. Understanding how STEM students, based on enrollment classifications, are being allocated more or less funding is necessary to identify how to support them with other resources (i.e., Alliance communication, state funding). Although this finding is represented the strongest in policy language and disbursement of COVID-19 related funding in a deficit manner, there are counterexamples of institutions addressing the disproportionate impact on segregated groups.

One institution changed its tuition costs to better support its part-time students during the pandemic. The change made students pay per course versus part-time students subsidizing the costs of full-time students taking more than 12 credit hours. The Illusion of Compassionate Divides finding further illustrates how "neutral" policies and institutional crisis responses can segregate populations and either assist them or limit their access to resources (i.e., funding). When creating policies, especially in times of crisis, the impact of segregation needs to be considered. The reality shaped by bringing the theory and text together spotlights a potential role for Alliances and similarSTEM education networks. For instance, Alliance leadership could have considered facilitating the sharing of best practices among member institutions on how to deal with the different ways the various policies were sorting students.

## "Stay in Your Lane Policymaking": Concretizing Barriers to Accessing Resources

> Segregated organizations maintain racial boundaries, channel resources, and help direct collective action. (Ray, 2019, p. 38).

The Barriers to Accessing Resources convergence highlights the responsibility and potential that institutions have been given to distribute resources to their students. This theme falls into Ray's (2019) description for legitimizing the unequal distribution of resources since the allocation of resources can lead to a reification of differential resources making it to underrepresented minorities. This dimension originates as a result of federal and state funding flowing from government coffers to schools and the resulting hierarchy of bureaucratic layers that place idiosyncratic restrictions on the use of funds. For example, the cover letter for the CARES Act requires that "of the amount allocated to each institution...at least 50 percent must be reserved to provide students with emergency financial aid grants…". At the state level, for Illinois, authority over the distribution of funds is given to the schools, but there are restrictions on how students can receive the funds, stating "schools must use the student funding to provide cash supports directly to students through direct deposits into their accounts or through debit cards." Ray (2019) argues that racial hierarchies can enforce "passive participation" that produces racial inequality (p. 40), meaning that these well-intended policies based on governmental hierarchies, where racism is already entrenched, foster participation downstream in the policy implementation that does not fully remediate the initial racism embedded within the upstream policymaking process.

For instance, Illinois' policy described aboe narrowly prescribes to institutions how the funding has to be allocated to students creates or reinforces a barrier for students who might not be able to pick up a debit card or who do not have a valid or consistent mailing address to receive one. Further, the policy requires that students have a bank account in their name to receive the funds, which is not always possible. There is a growing body of research on the "under-banked and un-banked" within the United States economy, which demonstrates that those with less access to formal banking mechanisms tend to be younger and racial/ethnically minoritized (e.g., Long, 2020). Therefore, the barrier of being under-banked or un-banked is reinforced or concretized by the Illinois student funding policy.

Yet, in other ways, the policies give considerable latitude to institutions, as evidenced by the discretion institutions have in determining who to disburse funds. This means that each institution can determine criteria to ensure the funds be given to the students who need them most, but with other limitations. For example, Northeastern Illinois University sent an email on April 27, 2020, to students explaining that CARES Act funds would be distributed based on spring credit hours ($42/credit hour) with Pell grant eligible students received an additional $15 per credit hour. Whereas Illinois Tech opted to use CARES Act funds to support students with unmet financial need in an April 28, 2020, email. Both approaches have merits and challenges that impact students in a range of ways—despite being well-intentioned. Understanding how broad policies and their implementation can limit the access to resources for URMs in STEM can help eliminate the unequal outcomes they cause. Yet, there did not exist an entity focused on translating the federal/state or institution policies for their realities on STEM students in particular. Against this view, an Alliance's role could be to help students navigate the various processes and procedures set in place to access funds or receive support. Specifically, creating institutions specific guides for STEM students on how to receive support to alleviate confusion on processes that involve multiple steps and time. Additionally, identifying policies that are more systemic in nature (e.g., un-banked students) and advocating for flexibility or alternative to navigate around the issue, are actions Alliances might have considered.

## "Time Ain't' Money Policymaking": Onerous Administrative Burdens on People's Time

> For instance, people in the welfare system often experience time as daily management of permanent "crisis" given insufficient resources [. . .], and forced waiting is a "psychological cost" welfare bureaucrats impose on recipients to show their time has no value [. . .] (Ray, 2019, 37).

Our final diffractive engagement underscores the tension that colleges and universities, and broader institutions, dictate how time is spent within, or engaged with, the institution through their policies and administrative practices. Ray (2019) provides examples of onerous burdens the welfare state places on people that create obstacles and barriers and reinforce tropes that have disproportionate impacts on specific communities. Similarly, reading our texts through this portion of Ray's (2019) theory revealed that institutional decision-making impacted students' availability of time in numerous ways. For example, institutions tended to create temporal efficiencies that benefit the institutions, but create obstacles for students. Students were often left to decipher statements like "in the coming weeks" or "please check [Institution] site for details." An additional instance of this lack of clarity included directing students to web pages and emails for up to date communications without giving any time frames on how regularly updates would be provided. Taking this to its extreme could mean constantly updating the web page or checking email waiting for updates, which restricts the time of individuals with competing demands.

Another constraint on students' time involved requiring low-income and under-resourced groups to expend additional resources to determine eligibility for means-tested programs. This came through in both communications to students (e.g., "the fund aims to provide eligible students facing short term, non-reoccurring financial emergencies with help in the form of grants that range from $100-$500") and communications from federal agencies to institutions (i.e., "visit the Department to determine eligibility"). There are two consequences of this sort of policymaking and communication. First, it harkens the metaphor of the 'solvent-solute challenge,' which asks—are students incorporated into the institutions, or are institutions incorporated into students? Ray (2019) makes the case that a little of both is happening. On average, institutions are more capable (financially and organizationally) of serving students' needs than students are at attending to an institution's practices. Thus, placing burdens on students has a greater chance of harming students than reorganizing institutions or tapping into intermediary institutions like LSAMP to provide complementary support. Finally, time constraints assume an elevated Baseline. "Please continue to check webpage," presumes an elevated baseline of capacity from students and families. The insufficient or erroneous baseline being students have the basic resources with which to access the school's online resources, in a consistent and uninterrupted manner unlikely to interfere with their academic progress, which is not a reasonable assumption and therefore an unhelpful baseline. This is heightened amid a focusing event that is reorienting numerous touchpoints for individuals. Here again, Alliances are positioned to advocate for what students are experiencing to better guide interventions that aim to connect with these students. Specifically, this could look like an Alliance using their coordinators on each campus to streamline communication that includes specific details that alleviates any confusion or additional interpretation for students. Ultimately, an Alliance cannot assume that all institutional communications and actions are adequate, there is a need to be proactive versus reactive when it comes to supporting STEM students who are navigating a crisis.

## Implications for Policy, Practice, and Research

The totality of our findings begins to make plain the numerous ways the policymaking and communication ecosystem perpetuate racialized harms in material and latent ways for students. We also noted the role LSAMP could play in ameliorating many of these concerns. These ancillary suggestions are not to second-guess the (in)actions of any particular Alliance or institutional leadership. We applaud many of the thoughtful, creative, and timely actions taken to support students in an unprecedented situation. Instead, the goal

**TABLE 3 |** Matrix of stakeholder recommendations to support URM STEM student success amid a crisis.

| | Alliance Leadership | Institutional leadership | Site Coordinators/STEM faculty/Student affairs Professionals | Policymakers |
|---|---|---|---|---|
| Academic | • Create or support the creation of resources that share best practices, train site coordinators on the information and disseminate to their campus | • Proactively create academic policies for times of crisis<br>• Allow students the option to choose pass/fail or letter grades for their courses | • Adjust academic requirements (i.e., lessen the workload required for courses)<br>• Share institutional resources that can support students who need assistance balancing school (i.e., tutoring, writing center)<br>• Adjust the accessibility of institutional resources (i.e., extend tutoring hours, offer online tutoring) | |
| Socioemotional | • Follow up with institutional leadership (i.e., provosts, presidents) about campus response frequently, share best practices, share concerns of STEM students and LSAMP staff/faculty | • Proactively create policies or plans to address the wellbeing of students on and off campus<br>• Minimize the steps expected of students to take to access resources | • Advocate for transparent communication that includes specific steps to access needed resources or processes, include dates of deadlines or when information will be updated<br>• Provide opportunities for students to communicate their needs/ concerns | • Consider the workload required of students in the creation of policies (i.e., multiple steps to apply for funding) |
| Financial | • Share best practices among member institutions on how to navigate how policies are sorting students | • Create institutional specific guideline of how to receive financial support that is detailed, time specific and includes on what date the information will be updated | • Create policies to allow student workers to receive payment even if not physically on campus due to a crisis<br>• Follow up with STEM students connected with the Alliance to assist them in navigating receiving financial support | • Distribute funds more equitably across student type (i.e., full-time, part-time)<br>• Identify gaps in policies that address the disbursement of funding to students and allow for institutions to address accordingly (i.e., students who do not have accounts in their name or the ability to come to campus to receive a debit card)<br>• Be in conversation before, during, and after the crisis with the Alliance to address how to improve in the future/address present concerns<br>• Approve follow-on supplemental legislation and continue to provide clear and unambiguous guidance to local institutions on allowable uses of funds and best practices |

of our analysis was to be imaginative in terms of what could have been done, as revealed through our diffractive reading of the texts. In the classic movie franchise, The Matrix, the rogue computer program, The Merovingian, opines that "choice is an illusion created between those with power and those without"—meaning that in any given situation the potential avenues of recourse are determined by those with relative power to set the parameters of the situation. We understand URM STEM students to be agentic, resourceful, and resilient (Harper, 2010; McGee, 2016) but recognize that their individual efforts are circumscribed by historical, policy, and organizational realities that do not always work in their favor. Therefore, our implications, summarized in **Table 3**, were developed in the spirit of being generative to enhance the STEM education community's ability to respond to the ongoing pandemic and prepare for future crises. Specifically, we focus on different stakeholders with varying dimensions of power that have some responsibility of dictating the realities that exist in the face of an educational crisis like the COVID-19 pandemic.

## LSAMP Alliances as Organizational Buffers

Our initial contribution in terms of recommendations is encouraging Alliances to embrace what we call the role of Organizational Buffers during focusing events that have the likelihood of harming the URM STEM ecosystem. As **Figure 2** depicts, Organizational Buffers position themselves between the potentialities of policies and communication and students. Similar to our diffractive reading of the texts, Organizational

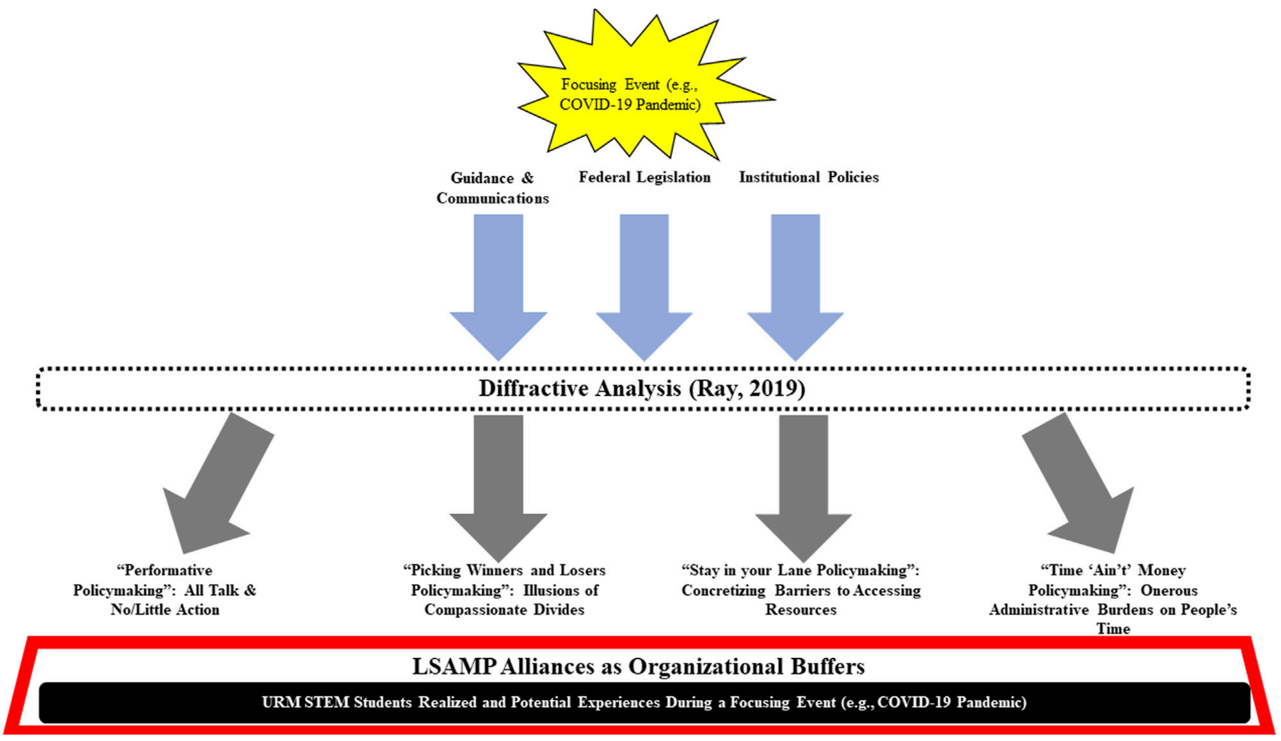


**FIGURE 2 |** Updated Diagram Reflecting the Potential Role of LSAMP as Organizational Buffers During Focusing Events.

Buffers filter policies and communications in ways that are cognizant of preexisting racialized realities and work within the resources and leadership existing in the Alliance to support students in complementary and supplementary ways. Specifically, this means sharing best practices early, and often, with fellow coordinators and institutional leaders in the Alliance, creating a controlled and coordinated space for rapid implementation, iteration, and improvement. For instance, quickly convening the governing board of the Alliance to brainstorm ways to support URM STEM students explicitly expands a function of an already existing structure in the LSAMP to be responsive to the realities of an emerging opportunity and threat. The remaining sections build on this metaphor of LSAMP as Organizational Buffers and highlight additional recommendations for policy, practice, and research targeted at different audiences.

## Leveraging Federal and State Government Leadership

As we write, new, more virulent strains of the COVID-19 disease are spreading, the national vaccination operation is still ramping up, and Congress is locked in a partisan battle to pass a new round of relief funding for various sectors. Likewise, institutions are planning for the upcoming fall term amid declining resources and a cohort of recent graduates are entering into an uncertain labor market. While we cannot predict the future, we believe it is critical to start applying lessons learned from the immediate past as organizations begin to chart paths forward in ways that we hope are transformative and equity-minded, not just additive.

One obvious policy actor is the federal government, including Congress, the executive, and federal agencies. Based on insights from the findings, we note that Congress's legislative language and accompanying regulatory language from federal agencies should aim to streamline and collapse administrative procedures that reduce workload and, therefore, time to complete processes and gain access to valuable and often life-saving resources. Also, government entities should prioritize authorizing policies not just for maximum flexibility, but provide proactive accountability metrics that center equity (McNair et al., 2019) and hold institutions—or direct funded bodies—to adhere to said practices.

## Institutional Interventions

In terms of institutions, we suggest that various actions, such as crafting emergency policies, funding distributions, overall student support, and interaction with the federal government, should have two primary considerations. First, the broadest and most lenient definition of funding eligibility and resources to best accommodate local needs centered on equity should be adopted. Second, institutions must conduct proactive outreach to vulnerable subgroups likely to be disproportionately impacted by the pandemic. This is an area where LSAMP as Organizational Buffers can be consequential partners given the inroads and interventions they already have established with students.

## Reimagining Research

Finally, in terms of setting up a research agenda to build on this project, we encourage future studies to build on the concept of LSAMP as Organizational Buffers. Potential questions include what focusing events are LSAMP best positioned to engage; who within an Alliance's structure is best positioned to coordinate the activities of the Organizational Buffer; and how can LSAMP as Organizational Buffers be assessed. Another area for research is extending the intersection between STEM education and policy analysis concerned with students' racialized realities. Additional research in this area would yield a more remarkable ability to map students' intersectional realities that this paper did not engage with as substantively.

Furthermore, we assert that understanding initial actions and messaging in a crisis is critical in aiding how educators and researchers learn from the situation because of how these early efforts often set the baseline for future actions in a policy cycle (Kingdon, 2013). Building on this proposition though, we encourage future research to address other timeframes in this and other crises (e.g., mid-pandemic or post-election periods) both as standalone units and across time frames. In particular, we suggest future researchers consider ways to analyze how messaging and policies shifted, changed, or stayed the same based on timeframe and the realities of the crisis. Finally, case study research that gathers insights into stakeholders impacted by the policymaking process and that receive organizational communication could yield insights into the policy implementation process as experienced by people within different but related contexts. By seeding new intellectual avenues and encouraging policymaking and communications that foreground equity, LSAMP have the potential to be better positioned to support URM STEM student success during the net local, national, or global issue.

## DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https://www.openicpsr.org/openicpsr/project/132401/version/V1/view.

## AUTHOR CONTRIBUTIONS

DM and KD contributed to the conception, design, and initial proposal of the study. DM, VC, and MA collected all the data and DM uploaded them to the data analysis software. All authors participated in at least two of the three data analysis phases. All authors wrote initial drafts of various sections of the manuscript. DM wrote drafts of the introduction, theoretical framework, and research design. VC wrote a draft of the literature review. VC, MA, and KD wrote the first draft of the findings. KD wrote a draft of the implications and conclusion. All authors contributed to editing the manuscript, with DM coordinating subsequent revisions. All authors have read and approved the submitted version.

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# Activating Social Capital: How Peer and Socio-Emotional Mentoring Facilitate Resilience and Success for Community College Students

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This article details the impact of the intensive mentoring model, through faculty-to-student and peer-to-peer mentoring, utilized in WAESO-LSAMP community colleges. We pay particular attention to the practice of socio-emotional mentoring, the development of a "mentoring chain," and the impact of communities of support on student and faculty participants. Specifically, we discuss how these separate modes of mentoring impact students from underrepresented students in developing and activating social capital, developing collaborative support systems, fostering confidence and self-efficacy, combatting impostor syndrome and stereotype threat, and embracing the importance of failure in the scientific process. Methods and data include qualitative analysis of forty-six in-depth interviews with program participants, including faculty mentors and community college students, at three community college sites within the WAESO-LSAMP alliance. We address specific implications for faculty working with underrepresented STEM community college students and provide evidence of best practices for setting up a community of support that leads to academic and personal success.

**Keywords: mentoring, peer mentoring, self-efficacy, resilience, social capital, community college, underrepresented students**

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## INTRODUCTION AND LITERATURE REVIEW

Critical and intentional mentoring impacts students, particularly underrepresented STEM students, including black, indigenous, people of color and also low-income, first generation college students, in important ways, including their identity development (Eagan et al., 2017; Estepp et al., 2017; Malone and Barabino, 2009), self-efficacy (confidence in performing essential parts of their studies) (Chemers et al., 2011; Crisp et al., 2017; Estepp et al., 2017), commitment to STEM education, and long-term success (Crisp et al., 2017; Dika and Martin, 2018; Hurtado et al., 2009). To best address this critical student development, mentoring should strategically develop social and cultural capital, provide diverse communities of mutual support, and intentionally facilitate the development of self-efficacy and resilience (Banda and Flowers, 2017; Beals 2019; Hurtado et al., 2009; Hurtado et al., 2015; Revelo and Baber, 2018). Critical mentoring has the ability to impact attraction and recruitment of underrepresented students to STEM as well as support their retention, progression, and long-term success in various STEM environments (Hurtado et al., 2009; Dika and Martin, 2018; Monarrez et al., 2019).

Furthermore, critical mentoring is important for promoting and supporting diverse networks amongst underrepresented STEM students. Research programs for underrepresented students like the Louis Stokes Access to Minority Participation (LSAMP) that incorporate intensive mentoring are necessary to increase diversity in the workforce, particularly in biomedical and science fields (Fuchs et al., 2016). Beyond the broad goals of increasing and supporting diversity, LSAMP intensive mentoring environments facilitate faculty-led undergraduate research experiences that have a multitude of positive academic and social outcomes (Kim and Sax, 2009). Intensive LSAMP mentoring can lead to increased self-efficacy and confidence in working with esteemed faculty, both of which are important as underrepresented students often feel uncomfortable reaching out to faculty for support (Schwartza et al., 2016) in college due to fears of being seen as incompetent or like they do not belong (Baker, 2013).

The remainder of this article will detail the way that intensive mentoring takes place and impacts underrepresented students in STEM fields. Particular attention is paid to the important role of social capital (Baker, 2013; Mondisa, 2020; Schwartza et al., 2016) and how students effectively develop strong networks of support and camaraderie that are essential to their growth and success (Mondisa and McComb, 2015). We discuss how the development of "mentoring chains" strong, authentic, and diverse communities of mentors - influences the diverse forms of support given by different members within the community. We discuss the role of various community members in helping foster confidence which leads to self-efficacy (Estrada et al., 2018; Fuchs et al., 2016; Starobin et al., 2016), and resilience through non-technical training (Hochanadel and Finamore, 2015) facilitated by both peer and faculty support. This ultimately leads to a community where students feel supported, like they belong, and have the necessary tools and social capital to be successful, and the confidence and problem solving abilities to be resilient in the face of challenges (Hochanadel and Finamore, 2015).

## ACTIVATING SOCIAL CAPITAL

Social capital theory is useful for identifying the key strategies of effective mentoring relationships, especially for underrepresented students (Mondisa, 2020; Hezlett and Gibson, 2007). Social capital theory asserts that relationships are essential for providing resources necessary to reach desired goals, especially in higher education (Mondisa, 2020; Hezlett and Gibson, 2007). Mentoring communities are places where this social capital is developed and contributes to the success of underrepresented STEM students (Mondisa and McComb, 2015). The successful development of social capital in STEM is crucial for educational success (Mondisa, 2020). Intentional mentoring strategies are vital for underrepresented students where the development of social capital improves educational outcomes (Saw, 2020). Integrating the development of social capital within the mentoring strategy offers promise to enhance career and organization development (Hezlett and Gibson, 2007). The social capital accrued during student's time in college provides individuals with a starting foundation, "like the first pennies in a child's piggy bank that can be cultivated and support their long-term career and personal goals" (Mondisa and McComb, 2015, pg. 158).

Both the quality and quantity of connections that underrepresented students make with individuals and organizations on campus determine their likelihood of success (Museus, 2020). It is often assumed that social capital is gained by students through their connections to faculty, as faculty often work as gatekeepers to their discipline and to the support networks that provide avenues for obtaining social capital. However, critical mentoring should also include social and cultural connections with other peers in the STEM environment in an effort to develop a shared sense of space and community within spaces that are often seen as exclusionary by underrepresented students. While faculty mentors connect mentees with other sources of campus support, which students can then utilize to expand their network (Museus and Neville, 2012), peer connections and a shared sense of community ultimately embed students within disciplinary environments that they seek to join.

Creating intentional social networks for underrepresented students to meet others not only helps to promote social capital, it also leads to the development of an authentic social community of peers who share similar backgrounds, experiences, goals, and challenges (Museus and Neville, 2012). This social community becomes a source of mutually beneficial, shared development by engaging in "an environment where like-minded individuals engage in dynamic, multidirectional interactions that facilitate social support" (Mondisa and McComb, 2015, pg. 152).

Social capital and access to networks is important for underrepresented students as a result of the hidden curriculum in higher education, where organizational behavior is often structured around middle- and upper-class values (Rist, 1970). When this cultural capital is rewarded, it can lead to students from underrepresented backgrounds feeling isolated and like they do not belong within the academic environment (Rist, 1970). Socialization into these spaces is influenced by peers, social networks, and values. The hidden curriculum of higher education, and STEM fields particularly, leads to unclear expectations tied to racial or class background, and leads to challenges in developing effective strategies of communication, collaboration, and relationship building–all critical for success in STEM education (Jackson et al., 2016; Stanton-Salazar, 2011.) The hidden curriculum ultimately reproduces race and class inequalities in higher education (Royster, 2003) and leads to differential attrition rates by race and social class (Graham, 2019). Faculty are necessary for deconstructing the hidden curriculum (Hansson, 2018) and the development of collaborative skills and effective communication is strongly influenced by peer support and community (Stolle-McAllister, 2011).

Underrepresented students often desire multiple kinds of mentoring relationships and collaborative experiences because having a variety of networks allows students to have different needs addressed by different individuals. This in turn facilitates the development of social capital (Graham, 2019). Having varying types of mentoring relationships across the diverse spaces in academia helps students develop skills that are necessary for academic and social engagement and promotes emotional development through socioemotional mentoring. While the engagement with various types of mentoring is useful, if these networks are not embedded within disciplinary environments students risk feeling isolated and like they do not belong within the key space of their academic socialization.

Embedded disciplinary support systems can positively impact the experiences of underrepresented STEM (Jackson et al., 2016). Mentorship helps to foster an environment of belonging and support, personal transformation, and professional development (Afghani et al., 2013). Mentors provide students the academic and social support they need to succeed within their STEM discipline. One study on underrepresented STEM students highlights the significance of mentoring for long-term STEM success (Griffin et al., 2010). Findings indicate the continuing significance of fostering positive mentoring relationships to facilitate student persistence, addressing exclusionary climate and disciplinary environment issues, and the representation and support of faculty of color in STEM fields (Griffin et al., 2010). Engagement with these issues has a positive impact on the development of self-efficacy, a student's commitment to academic goals, and feelings of empowerment to reach desired goals, especially in terms of challenging the impostor phenomenon and fears of failure within a challenging environment (Beals, 2019).

## The Importance of Peer Support

Peer support is also important in developing and activating social capital, especially through the provision of both socio-emotional and academic support, which leads to a more successful integration into campus community and culture for students (Moschetti et al., 2017). Targeted initiatives, such as summer bridge programs, support underrepresented students as they begin to build social and cultural capital. Through connecting peers from similar backgrounds prior to the start of college while facilitating engagement with peers and faculty, Summer Bridge provides access to STEM environments that facilitate meaningful participation in academic activities, which both builds and strengthens student's social and professional networks (Stolle-McAllister, 2011).

Peer mentors can act both as guides who share information and as friends who provide psychosocial support, such as normalizing common struggles and decreasing feelings of isolation. Peer mentoring provides support to students as they develop a sense of belonging and facilitates the development of positive science identities (Zaniewski and Reinholz, 2016). Similarly, when important peer groups both value and support STEM learning and environments, these peer supports help to validate sense of belongingness in STEM fields (Leaper, 2014). Peer support also mitigates negative aspects of underrepresented student experiences (Watkins and Mensah, 2019). Institutions can and should provide structures where supportive peer networks can emerge to support underrepresented students in STEM. Peer support also impacts individual's willingness and confidence to pursue STEM careers. STEM peers have been found to influence motivation, which in turn predicts their intent to pursue a STEM career (Robnett, 2012).

## Mentoring Chains

### Community, Confidence, Self-Efficacy, and Social Capital

The intensive mentoring facilitated through formal academic programs, like LSAMP, allows individuals to share their academic, social, and cultural experiences with themselves, their peers, and faculty mentors (Kendricks et al., 2013). Program facilitated mentoring is primarily conducted through a network of faculty who have a common interest in the student's retention and academic success, and who nurture the student by integrating academic advising into social and professional meetings with students. Students in these programs perceive mentoring as the biggest contributing factor to their academic success (Kendricks et al., 2013).

Broader networks of mentors that include graduate and undergraduate students have been shown to be effective in providing important support for students and scholars. Mentoring triads (post-graduates and faculty each assisting in mentoring undergraduates) provide students with resources and psychosocial support (Aikens et al., 2017). Closed triads, where post-graduates, faculty, and undergraduate students collaboratively communicated with each yielded the best results (Aikens et al., 2017). This evidence may point to a network or chain of mentors yielding the most optimal social support.

Collaborative mentoring chains have also been shown to influence the development of a strong academic identity and self-efficacy which can lessen the negative impact of STEM disciplinary environments for underrepresented students (Estepp et al., 2017; Hurtado et al., 2015; Rodriguez et al., 2019). The development of confidence and self-efficacy are lifelong processes. Students who lack confidence but currently occupy positions within STEM fields may be faced with impostor phenomenon, where they feel like despite their accomplishments they really are not competent in their field (Clance and Imes, 1987). Furthermore, those who are from underrepresented groups may suffer from the negative effects of stereotype threat (Steele and Aronson, 1995), where there is an increased fear of being judged on the basis of societal stereotypes about their group membership rather than their own merit. The psyche of other underrepresented students are sometimes negatively impacted just from being aware of the additional challenges they face because of their identity while being in their STEM field (Pietri et al., 2018). Both impostor phenomenon and stereotype threat can lead to underperformance in academic settings (Clance and Imes, 1987; Steele and Aronson, 1995; Pietri et al., 2018).

Self-efficacy is an essential component to positive outcomes in underrepresented STEM students (Jensen et al., 2011), especially in combatting impostor phenomenon. Faculty-student mentoring is a key component of the student experience that has been shown to significantly influence confidence and self-efficacy (Estrada et al., 2018; Fuchs et al., 2016; Starobin et al., 2016). Mentors act both as guides who share information and as caring friends who provide psychosocial support, including normalizing struggle. Faculty-student connections help students to develop a sense of belonging and positive science identities (Zaniewski and Reinholz, 2016). Faculty-student mentoring has also been shown to impact confidence and self-efficacy for student's future pursuits. Both the development of a science identity and self-efficacy are important factors in student's motivation to pursue long-term goals (Estrada et al., 2018).

Mentors are an important source of confidence for students. Having a respected role model who believes in student's potential is vital (Carpi et al., 2017). Formally mentored undergraduate research experiences broaden student's knowledge about career options, prepare students intellectually and technically for further studies, provide the conditions under which a student may fall in love with the scientific pursuit, and provide a boost of confidence for students as they contemplate their next steps (Carpi et al., 2017). Student-faculty mentoring relationships also influence doctoral students as they realize their potential regarding aspirations of entering the professoriate (Alston et al., 2017), indicating that the effects of this mentoring model benefit individuals from grade school through the completion of advanced degrees. Peer mentoring has also been shown to have significant influences on confidence and self-efficacy by fostering professional skills and confidence in developing scientists (Tenenbaum et al., 2014). Peer mentoring has helped in demystifying college and graduate school for students, learning how to prepare for college and graduate school, the application process, and how to plan for after graduation (Meza et al., 2018).

## Collaborative Mentoring and the Facilitation of Non-Technical Skills Training

While collaborative mentoring facilitates the development of confidence and self-efficacy and challenges impostor phenomenon, it also contributes to the development of important non-technical skills. Non-technical skills have become increasingly paramount in student and career success, particularly in STEM fields. Emerging graduates are not only required to have quality technical skills; they also must excel in professional skills to be successful in their respective careers. These skills include teamwork and communication, ethics, global awareness, creative problem solving, and leadership experience (Kulturel-Konak et al., 2013). Hochanadel and Finamore (2015) state, "Faculty should not focus on making just good grades, but how to challenge that person and teach them to create solutions . . . teaching a growth mindset and grit facilitates long-term goals and how to achieve them." Technical skills and good grades are important when it comes to success within STEM fields but student and career success is about much more than a grade.

Mentoring has been shown to help expose students to professions, professionals, and professional environments to improve non-technical skills, such as leadership skills and communication. Along with fostering an environment of belonging and support, personal transformation, and professional development, mentoring has also been found to motivate students towards STEM fields, increase leadership abilities and self-confidence, and heighten awareness of the need for diversity in STEM-related fields (Afghani et al., 2013). The LSU–HHMI Professors Program has helped students to achieve various important skills, including: 1) Realization, after attending a learning strategies presentation or meeting that what they are currently doing is not working, 2) An honest commitment to systematically identify exactly what is not working, 3) Changes in mindset about their ability to learn the "hard" subject matter, 4) Committing to work through the plan of action, 5) Following through on their commitment which prevents them from relapsing into old academically destructive habits and ways of thinking, and 6) Continuous improvement which develops sustained personal pride and great satisfaction in the outcome which propels them to maintain what they have obtained (Wilson et al., 2012). Mentoring also demystifies graduate school for students, especially in terms of learning how to prepare for graduate school, the application process, and how to plan for after graduation (Meza et al., 2018). For many first-generation college students, access to mentors opens new doors and prepares them for the college and graduate school requirements.

While it is well researched that mentoring impacts underrepresented students in a variety of ways, students, faculty, and STEM broadly would benefit from developing more intentional, intensive mentoring chains that embed collaborative support, socio-emotional development, and the importance of non-technical skills training. Underrepresented STEM students face unique challenges while attending higher education. Mentors from a variety of backgrounds and statuses within the institution who are eager to help underrepresented students thrive within STEM fields can effectively combat these issues.

The findings of this paper are results from an external, independent evaluation of the WAESO-LSAMP program. The guiding question that led to these results was, "What does mentoring in the WAESO-LSAMP program consist of and how does it impact student participants?" I hypothesized that mentoring would be an important program component that students found valuable for learning STEM. However, as fieldwork progressed, I noticed the variety of ways that mentoring took place within the WAESO-LSAMP program. The remainder of this article details the impact of this style of mentoring for community college students within the Western Alliance to Expand Student Opportunity (WAESO) alliance of the Louis Stokes Access to Minority Participation (LSAMP) program (henceforth known as WAESO-LSAMP). This article addresses the ways that various WAESO-LSAMP intensive mentoring strategies lead to the development and activation of social and cultural capital, the embedding of mentoring chains within STEM environments that incorporate faculty and peers, and the critical skills of resilience in challenging academic settings.

The findings of this research are focused at the community college level. Understanding what occurs within the community college setting for underrepresented students is important for a number of reasons. Community colleges are an important component of increasing diversity in STEM fields (Bahr et al., 2017). Many underrepresented students, especially low-income students of color, begin their studies at community colleges (Contreras, 2011) making it the gateway into more advanced degrees if matriculation and transfer are successful. The experiences and opportunities afforded to these students are instrumental in developing pro-academic behaviors and aspirations (Baker, 2013) which can influence their success in obtaining more advanced degrees after their community college experience ends.

Furthermore, detailed information regarding the role that community colleges play in increasing representation of underrepresented students in STEM is lacking (Wang 2013) which is unfortunate, as these institutions have great potential in training a large number of future STEM scholars to address a nationwide shortage of these individuals (Bahr et al., 2017). As the United States continues to debate their role in funding or supporting free or greater access to community colleges, especially for low-income and other underrepresented populations, understanding the various ways these programs and environments impact the future success of these students will only increase in importance.

## METHODS OF DATA COLLECTION

Examining the activities and mentoring within the WAESO-LSAMP community college population is particularly useful for this topic. WAESO-LSAMP has been active since 1991, and is one of the original LSAMP alliances. Every year since 1991, the WAESO-LSAMP alliance has consistently reached its goals of increasing the number of underrepresented STEM students within their program as well as their attainment of various degrees. Furthermore, WAESO-LSAMP alliance schools are on track to have equal numbers of underrepresented STEM graduates as the general populations of the states in which they reside, which has been a goal of the WAESO alliance since 1991. Community college participation in WAESO-LSAMP has been strong since 1991, and community college students are given the same opportunities to participate in undergraduate research, conference participation, and mentoring as students at 4-years universities. While most WAESO students participate in undergraduate research, a large number of community college students participate in Summer Bridge programs that are designed to increase the likelihood of enrollment and success at the community college. Since Arizona State University is the home campus of WAESO-LSAMP, it makes an interesting environment for collaboration and transfer between the community colleges and the 4-years institutions in the region.

The first author worked with the WAESO-LSAMP program staff in order to obtain enrollment information from each institution included in a sample of WAESO-LSAMP community college campuses. This information includes student enrollment and contact information as well as faculty mentor contact information. I made first contact by introducing myself at the annual governing board meetings to increase rapport and establish a relationship with campus stakeholders. I also frequently contacted Summer Bridge program coordinators by telephone or e-mail, letting them know when I would be visiting their campus and asking for their help in recruiting students. This included having the faculty mentor or contact send an e-mail to the students letting them know that I was a program evaluator and encouraging them to participate in an in-depth interview. Faculty mentor support was critical in recruiting students and gaining their trust. I also made individual contact with students from the enrollment information via e-mail as well as in person at undergraduate research conferences and Summer Bridge activities, inviting them to complete an in-depth interview.

Sampling was two-fold, happening at the institutional and individual level. The first stage in sampling was to select a sample of institutions from the entire population of WAESO-LSAMP community colleges. The program director identified potential institutions as having greater than average numbers of participation or already funded summer activities. Using a non-probability purposive sampling technique, I selected three of these identified programs to be included in the study. All of these institutions are considered Hispanic Serving Institutions (HSIs) and public, associates colleges with varying degrees of transfer and student status. The names of these institutions and their contacts have been redacted to protect the privacy of the schools and participants. It is within this sample of institutions that the second stage of sampling took place. **Table 1** provides information regarding each of the institutions.

I used non-probability, purposive sampling techniques to select the individuals to interview in-depth within each institution. The student sample was selected using the enrollment information provided by the WAESO-LSAMP program staff. I completed 46 in-depth interviews which took place at Summer Bridge sites, including faculty directed research groups, and immersive summer classes, by the end of my fieldwork activities. Student interviews accounted for 37 of the interviews and 9 interviews were with faculty participants. Of the student interviews, 19 were with students who did faculty directed research and 18 were with Summer Bridge participants. Of the faculty interviews, 4 were independent research advisors and 5 were Summer Bridge faculty.

The in-depth interviews were semi-structured. For students, I assessed aspirations, expectations of the program, program experiences, and suggestions for structuring the program to enrich their experience and enhance their learning. I also asked them about aspects of their lives that might intervene to affect their ability to meet project objectives, such as their family circumstances and demands, their economic situation, and any other issues that might affect their performance in the WAESO-LSAMP program. Separate interviews were given to faculty participants where I discussed their program activities, such as mentoring and professional development of students. **Table 2** displays the demographics of students that were interviewed as a part of the WAESO-LSAMP evaluation project. All students interviewed for this project identify as underrepresented by race and/or ethnicity within STEM. This is a pre-requisite to participate in the program. While the intersectional identities of these students is important and may influence experiences within the program, the impact of the intersection of race and gender was not addressed in this paper due to time and space limitations and will be explored in future work by the first author.

Interviews lasted between 30 and 90 min, with shorter interviews taking place when students had time or scheduling constraints and longer interviews taking place when two or more

**TABLE 1 |** Institutional breakdown.

| Institution | Carnegie type | Students | Faculty | Total |
|---|---|---|---|---|
| College 1 | Public, Associate's Colleges: High Transfer-Mixed Traditional/Nontraditional; HSI | 8 | 2 | 10 |
| College 2 | Public, Associate's Colleges: High Transfer-High Nontraditional; HSI | 6 | 2 | 8 |
| College 3 | Public, Associate's Colleges: Mixed Transfer/Career and Technical-Mixed Traditional/Nontraditional; HSI | 23 | 5 | 28 |
| Total | 3 | 37 | 9 | 46 |

**TABLE 2 |** Participant demographics.

| Student gender | | Faculty gender | |
|---|---|---|---|
| Female | 20 | Female | 5 |
| Male | 17 | Male | 4 |
| **Student Race/Ethnicity** | | **Faculty Race/Ethnicity** | |
| Hispanic/Latin@ | 27 | White | 4 |
| Native American | 4 | Hispanic/Latin@ | 4 |
| Black | 3 | Black | 1 |
| Middle Eastern/North African | 3 | | |
| **Student Involvement** | | **Faculty Involvement** | |
| Research Experience | 19 | Research Experience | 4 |
| Summer Bridge | 18 | Summer Bridge | 5 |
| **Total Students** | **37** | **Total Faculty** | **9** |

participants were involved. On average, individual interviews lasted almost 45 min. Participants were asked permission for the interview to be recorded for later transcription. All recorded interviews were transcribed and coded using Dedoose software. I utilized small focus groups in order to maximize the response rate. Of the 46 interviews, 12 students were enrolled using focus groups. These consisted of groups of 2-3 students. Since the groups were small, I was able to gather the same amount of information from the focus group interviews as I would have had they been individual interviews.

# RESULTS WITH DISCUSSION

This section addresses in depth the most frequently mentioned themes discussed by students and faculty as a result of their participation in WAESO-LSAMP activities. Themes discussed include the impact of collaborative mentoring, the mentoring chain that develops through peer-to-peer contact, the impact of the program on student academic growth, and the development of self-efficacy through learning to fail and challenging impostor phenomenon. These themes are each supported by numerous quotes from students and faculty that support the broader message about the process and impact of WAESO-LSAMP programing. I use quotes liberally, as I believe messages are best told through the direct language of participants and their own lived experience.

## Impact of Collaborative Mentoring

Mentoring proved to be one of the most impactful aspects of the WAESO-LSAMP program. Mentoring happened in various ways across the campuses and included one-on-one faculty mentoring with students who do faculty led research projects, peer-to-peer mentoring, as well as broad group mentoring that occurred during Summer Bridge programs. Of particular interest here was how mentoring networks provided support for professional and academic development, how faculty driven recruitment led to the development of self-efficacy, how learning to fail helped challenge impostor phenomenon, and the importance of mentoring to teach more than just technical skills and abilities.

## Academic Development and Student Engagement

The relationship developed through faculty-student mentoring provided students with opportunities necessary for professional growth and success, including formal and informal networking and coaching on how to present research across various academic spaces in their exposure to academia. For many students, WAESO-LSAMP provided their first experiences in these areas. These formal, guided interactions within academia provided students with more than just hands-on learning that results in developing technical skills. Faculty mentors additionally give students opportunities to gain social capital through networking. This social capital is crucial to progression in the field and higher education. This sentiment is highlighted in a quote that a WAESO-LSAMP student internalized from her faculty mentor, "The most valuable thing, (mentor] used to say was this," "Never close a door on an opportunity."

### Transition Into College and Impact on Confidence

This formal guidance through academia with a trusted advisor is particularly important for traditionally underrepresented students in STEM. Students often started out their WAESO-LSAMP experience feeling apprehensive and doubtful about their abilities and their likelihood of being successful. However, through working with mentors who recognize their potential, students slowly begin to realize their own abilities and potential for success. Mentors were able to identify students with potential that were unable to see themselves in certain roles because they are intimidated and doubtful of their own skills.

Faculty mentors encouraged these apprehensive students to apply to things like internships, research opportunities, as well as present research, even if they have had little experience presenting. It is important for students to be able to work with faculty who know the process and procedures of higher education and that the experience gained by participation in such activities, regardless of whether or not the student had ever presented before, is a normal and necessary part of the growth of the science identity and future success. This targeted influence also resulted in students gaining opportunities and support outside of their individual WAESO-LSAMP project. Here, a student notes how their encouraging WAESO-LSAMP mentor influenced their successful application for external funding. “There’s a scholarship here with (a stem program), so she was like, “Oh, you should apply,” and I was like, “I don’t think I’ll get it,” and then I applied, and I got it.

### Challenging Fears of Failure and Impostorism Through Experiential Learning

Students often start out their experiences with fears of failure or not being qualified for the work. “At first, I was kind of like really, me? Like you want me? Because I felt like when I presented, I stumbled a little too much . . . are you sure you want me on your team?” However, through the hands-on, challenging environments, students become empowered by the scientific method and how mistakes do not equate to failure, but actual growth–whether through scientific discovery or personal improvement.

I was afraid I would mess up a lot, because the word research on its own is kind of intimidating. So the research, the word, we give it so much power so that it intimidated me the first time, but once I was in it and I saw how (WAESO-LSAMP Mentor) was doing it so fluidly and we were so rigid, we were being so careful with everything. But by the end the semester we were the ones doing things at the same pace as [mentor].

Through these hands-on, authentic research experiences with faculty sponsors and their peers, students learned self-reliance, independence, trouble-shooting, and how to work on group projects with high pressure deadlines. Student research experiences in WAESO-LSAMP also opened their minds to opportunities that they had not yet considered for their academic lives. While many students aspire to be medical doctors, learning the process and problems of research and becoming engaged with academic life at their campuses inspired them to merge those areas, aspiring for Ph.D.’s alongside a medical degree.

Having that experience with (Mentor) made me want to do MD/PhD, which gave me understanding that I need to keep moving forward and I need to work really hard to be an eligible candidate for that program, for all the other programs. So in a way, that did help.

Through extended engagement in activities, students were able to capitalize on their increased motivation to accomplish their goals. These included traditional goals of graduating from community college, getting accepted and transferring into 4-years colleges, receiving competitive scholarships, winning awards, and formally joining the STEM industry job force. WAESO-LSAMP mentors are aware of the important connection they have with the WAESO central office, and see themselves as a team, working together to reach shared goals regarding student success and transfer.

Both institutions mutually benefit from this shared commitment and the partnership created through WAESO-LSAMP, as faculty and sponsored environments are doing necessary work to inspire, prepare, and socialize students so that they are excited to transfer and continue their academic journeys. By engaging with these environments, underrepresented students who had experienced challenges within traditional academic environments were no longer discouraged from seeking transfer into a larger research institution. Instead, they reframed their ideas about faculty and university life where faculty were supportive and presented themselves and their environments in such a way that students could visualize themselves in that position someday.

## Faculty Driven Recruitment and the Development of Self-Efficacy

WAESO-LSAMP’s unique mentoring strategy also has an impact on the development of self-efficacy and self-esteem. The mentoring relationship begins at the time of recruitment and is often faculty driven. Faculty are given freedom to reach out to students who they see as promising, regardless of traditional signifiers of success like exceptionally high grades or prior experience. The only requirement is that the student be part of an ethno-racial group that is underrepresented in STEM. Students are not filtered out due to low GPA or lack of experience in a research lab or in the classroom. Faculty mentors frequently discussed how they sought out students who may not have been qualified for other programs, and students sometimes discussed how they had been overlooked by other research programs due to GPA or other factors. This results in students who have non-traditional signifiers of promise being admitted into an environment where they can work on weaknesses within their academic portfolio through intensive experiences and does not simply allow only the already successful students to be granted entry into these important spaces. without other restrictive requirements that often filter out low-income, first-gen students of color (GPA, prior experience, letters of recommendation, Students mentioned that they feel honored and special when singled out by faculty to do research for them, which boosts their confidence.

I was just honored to have someone like her like say, “hey you want to do this, like you want to come over here and do this with me and with the people that are doing this?”. . .I was excited because I felt privileged because she’s already had it going on, and she explained the research to me, and I thought it sounds important, and I liked it, so I was really excited to get on.

Faculty mentors talk about promise and potential in ways that challenge traditional recruitment methods, like high GPAs, prior experience, and formal recommendations by other faculty.

When faculty have freedom to select students they see as promising, it results in dedication to their recruits. Their dedication contributes to the creation of an environment where students feel like their mentors authentically care for them and their success. In turn, students are encouraged to seek out resources and experiences because they feel like it is a welcoming, supportive environment (Beals, 2019). “[Mentor] kind of inspired me...to go [to Summer Bridge] because...the way he said it--it didn’t sound like a teacher or professor that was talking to me it kind of sounded like he was a brother. Like a big brother or you know like a homie or something like that.” Through these experiences, students begin to rethink what it means to work with a professor and develop skills to practice resilience in the face of challenges, resulting in them thriving in a challenging environment (Hochanadel and Finamore, 2015; Revelo and Baber, 2018; Beals, 2019). It was often the case that supportive and friendly mentors played a significant role in creating these welcoming spaces. This is especially important for students who are first-generation college students and other underrepresented students in higher education.

### Authentic Caring and the Impact on Retention

Faculty mentors effectively showing that they care for their students has a positive impact on the student's self-concept, science identity, and motivation to continue working. Students often noted that they like having people who supported them because it pushed them to work harder. Here, a student notes how having a supportive mentor influences her to keep working hard and to not give up. "Knowing that I actually have, you know, people that support me . . . I actually do better. As in I might not do the best, but you know I won't give up."

Students frequently noted that one of the greatest things they got from their faculty mentor was an increased excitement for the work, doing research, and their STEM field. Faculty mentors are excited about the projects they bring to their students, and their excitement and support influences the student's own feeling about the work. Part of this comes from the faculty rewarding traits that are central to science–curiosity and engagement (Beals, 2019). This is often a trait that faculty seek out when selecting future mentees. "I was the one student that asked all these questions in [mentor's] class and she was like "I like your curiosity" I was like "okay, I'll use it." That was amazing . . . I really loved that class. It changed everything for me."

WAESO-LSAMP faculty are aware of this impact and how important getting students excited about science is for their engagement and retention in the field. Here, a faculty mentor talks about this important part of the mentoring relationship. "It's really, I think it's that mentorship, the excitement of science starts to, you know, we stoke that sort of spark into a flame. And I'd say that is the biggest one." Faculty also frequently help students realize the real-world significance of the work that students are doing, translating lab procedures into altruistic outcomes, which helps students develop a passion for doing STEM work. This increases student engagement with the projects, which is important for retention. Faculty are aware of how important this is and work with students to incorporate their individual interests and questions into their research project, even if it was extra work. "She always went out of her way for us . . . She always saw what I was interested in and she never blocked me or told me it's time (to leave)."

## Learning the Positive Impact of Failing

In order to understand what factors contribute to effective mentoring, I frequently engage students in a conversation where they can express in their own words what they see as an effective mentor. Students shared similar ideas about what makes an effective mentoring relationship and whether or not WAESO-LSAMP faculty fill this role. The most frequently mentioned qualities that students seek in a mentor include availability to reach out and ask questions, support during the process of sponsored activities, encouragement when things get hard, empathy in the face of mistakes, and authentic engagement with students. Summer Bridge students especially mentioned how different it was to work with WAESO-LSAMP faculty as opposed to their high school teachers. For example, one student mentioned, "They are not like teachers, or how it was in high school. They make you feel like they're friends, you can talk to them." Students also mentioned that they felt a great deal of encouragement and motivation to keep working hard, and how good it feels to work through a project that was challenging. These interactions help decrease the distance between faculty and students, especially first-generation students, and lead to more enjoyable college experiences. The ability to recognize when students are struggling and need extra help and encouragement was important for students. Students, especially underrepresented students, are not always confident to reach out and ask for help in fear that it will negatively impact how faculty view them and their potential, which may amplify the negative impact of impostor phenomenon (Clance and Imes, 1987). Students were appreciative that faculty were able to "scan the room" and recognize when someone is not doing well and then reach out to help solve the problem.

She knows how to scan the room and be able to determine when a student is not doing as well as she would like . . . she's able to understand the area they need more help in . . . She's gonna find a way to help you get what you need . . . You see people who are like If there's a mistake made, you can see that they're super angry or irritated, and she's just calm . . . She's like, "It's fine. We're gonna fix this." It makes it easy to keep going, learning, and building from those mistakes.

This type of sustained and empathetic support and encouragement is critical for the intensive mentoring model. It helps students realize that making mistakes is often an integral part of the scientific process and the development of self-efficacy. One student noted a positive transformation in learning to fail, saying, "Now when I make a mistake, I know how to approach it, you know?" Through this work, students learn critical skills like independence, self-reliance, and how to thrive in the face of failure. Students frequently mention how empowering it is to learn how to fail effectively.

I was nervous . . . I don't want to mess up and I don't want to ruin everything. But (Mentor) did mention 1 day, "In research there are no mistakes. Because your mistakes could lead to something better." And then she mentioned one other research student that was there a semester before, her mistake actually improved the project. So that gave us a little bit of confidence right there. But the reason I enjoyed it most is when that mistake happened, because I was excited to figure something else out, something new.

These skills translate into real-world success once the WAESO-LSAMP experience is over. I had the opportunity to talk to students who had since transferred to 4-years colleges or universities as well as the workforce about any impact their experience had on their success post-WAESO. These students noted that the mindset they were able to develop through learning to fail effectively made them more successful in their current endeavors.

The development of this confidence and self-reliance resulted in the former student being able to trouble-shoot on the job and come up with a solution to a problem that his organization was having, using tools he learned through WAESO-LSAMP activities. "The first time I did it, I used their (Institutes] methods. And it didn't work, the bacteria didn't grow. So, the second time, I decided, "I'm not going to do the same mistake again," so I just did everything [Mentor] taught me . . . and it grew."

My work interviewing faculty mentors suggests that they have found a way to strike a balance between letting students figure things out on their own and guiding them when needed that results in the student developing important industry and technical knowledge, self-confidence, and independence. These mentors are aware of this important process and how challenging it is to facilitate. One faculty mentor explained that the method of allowing failure is less cost-effective and less efficient.

She (non-WAESO-LSAMP mentor] can probably get that same task done in 2 weeks that I can do in 2 months. But the learning experience that they built in 2 months is, failure really brings on the successes . . . I don't get the same successes that they do, because they can take a student that just started and get them to a point that they are doing high impact posters. For me, it might be a lot slower, but I think through failure you get a lot more successes.

Despite being less efficient or cost-effective, this method allows for the best learning because students fail and learn from their mistakes or learn something entirely unexpected. Not only is this good for the development of these important soft skills, but this approach was also described as less intimidating and helped students feel excited and engaged instead of frustrated and discouraged. It is also important to note that the WAESO-LSAMP faculty are aware that this method of mentoring is not always practiced by non-WAESO-LSAMP faculty within their institutions, suggesting that this intensive mentoring may be challenging the traditional culture of STEM education.

## Challenging the Impostor Phenomenon

The intensive mentoring that challenges traditional culture of STEM education is seen by faculty as integral for the type of growth and development necessary for student success. These environments that embrace the challenging environment of STEM research and learning while providing socio-emotional support to the student during the process of failing upwards help students reframe their views of higher education (Monarrez et al., 2019; Nevin et al., 2008; Revelo and Baber, 2018). Through their work with WAESO-LSAMP sponsored environments, many students mention that they realized their internalized self-doubt and fear was a part of something much bigger than themselves. Faculty helped them put a word to this–impostor phenomenon. Realizing that this was a phenomenon that many people, including their own mentors, experienced helped students overcome their self-doubt. Here, a student brought up learning about impostor phenomenon from their WAESO-LSAMP mentor and how they learned to manage these feelings. It is important to note here that the student brought up impostor phenomenon without me specifically asking about it. They mentioned this lesson as one of the beneficial things they learned through WAESO-LSAMP, therefore I probed them to speak more about it.

Out of the six boxes she had (on impostor syndrome), like the categories, I checked off five, all but one . . . I was like, "Oh my God! Okay." Before that, I never knew what term to use for it. I thought I was just expecting a lot of things from me. But turns out, its impostor syndrome...I remember her mentioning one part saying "Give yourself a pat on the back." I don't do that, though. But I kind of try to compliment myself. I tell myself, "Hey you did this. You're good. Now on to the next one." I keep telling myself those things.

Sometimes student's feelings of self-doubt are so strong that they question their abilities to be successful beyond WAESO-LSAMP. A number of students mentioned how important their WAESO-LSAMP mentor was–even when the students had been working with them for a semester or more–in terms of encouraging them to seek out experiences to help them grow beyond the WAESO-LSAMP environment. A nudge or statement of support from a faculty mentor can make all the difference in where the student goes next after their time at their community college.

First off, I was flattered. I was like "What, really?" You know. "Me?"...it was my first actual research. You know the impostor syndrome kicking in again from all angles . . . Then I asked her, she was like . . . "You've done everything good." And then she was like "You've got the skills don't worry." And then after that we just started building.

This sustained support for their students proved to be an effective strategy to help the student succeed once finished with their WAESO-LSAMP activities. Students often began seeking out other opportunities that they might want to try and went to their faculty mentor for support and guidance. It is important to note that faculty mentors are explicit about the competitive nature of some of these non-WAESO-LSAMP research experiences. In fact, they are aware that many underrepresented students in STEM face great challenges in terms of acceptance to these more competitive programs. They teach their students about the competitive nature and support them in their efforts. Here, a student discusses one time when this happened with them and how their mentor's support led them to success, even when their impostor phenomenon remained.

I told her (mentor) "I heard about this internship." She was like "Yeah, that's great. Go for it...It's not going to be that easy to get in.". . .She told me to apply there and then I applied . . . She wrote me my recommendation letter . . . And then I was waiting for a decision and then I got accepted. Yay, I got accepted...The director of the whole internship thing [e-mailed me] and she told me I was one of the best profiles. I was like "Maybe you got my resume mixed up. Not, that's not me."

### Student Accomplishment and Growth of Self-Efficacy

One part of helping students manage their impostor phenomenon utilized by WAESO-LSAMP faculty was a consistent emphasis on helping students recognize their own worth and potential while reminding them that their accomplishments were no one else's but their own. When working in such collaborative environments with a dedicated mentor, it is easy for students with self-doubt to forget that what they accomplish is "theirs" and a reflection of their own hard work.

I wanted to learn more about what environments foster this growth of confidence and feelings of self-efficacy. In my conversations with student participants, it became clear that the WAESO-LSAMP sponsored conferences and programming were often mentioned by students as being a catalyst for the internalization of feelings of pride and their own ability to be successful. Students that I spoke with mentioned that just presenting research gave them more confidence in their own abilities to do science. Presenting outside the walls of a classroom and in a formal academic setting with students from many other universities and programs is not something that can easily be replicated within a traditional classroom. This added component of competition, common in the academic world, is unfamiliar and uncomfortable for students. However, it results in students feeling more confident in their own abilities, increasing feelings of self-efficacy and overall pride in themselves and their own work, and also the confidence to continue this work in the future, despite their original feelings of being a fraud.

The second conference we went to It was like, "Oh, this is a breeze." It was so much better. And then time had lapsed, so I felt like I knew what I was talking about. I had put research in, so I wasn't so scared about feeling like I felt like a fraud (the first time.) I was there, like, I feel like this isn't my research. And I'm trying to present it. But it was a good experience . . . Then later on, I was like yes. I feel better about it.

While presenting in and of itself was beneficial for student's sense of accomplishment, self-worth, and challenging the impostor phenomenon, the opportunity to be formally recognized for their work through winning awards was particularly powerful. For many students, this was their first experience doing real research and presenting it in a formal setting. To be recognized formally with a tangible award was a big moment for their academic careers. Students who won awards or even just received a plaque for presenting noted how powerful this was for them, and proudly displayed their formal accomplishment for their friends and family to see.

Like those conferences. I've never done anything like that. It feels good. I feel like I'm doing something. I'm presenting something. And I can be proud of it. I have my little plaque they gave us from WAESO and have it on my shelf . . . I'm like, "Yay!" I'm so proud of it. Everyone asks. I'm like, "Yeah, I went to a conference. I presented something." It's something to be happy about, something to be proud of.

It is important to note that large scale efforts–like hosting or attending a conference–are not required to foster this type of growth in students. In fact, many students noted what they saw as the "little things" that they learned through WAESO-LSAMP that slowly accumulate and lead to feelings of greater self-efficacy and lessen impostor phenomenon. Note this remark from a WAESO-LSAMP research student. "It's kind of difficult to have a huge dream. But the little things you do, that kind of seem silly, they help you, they motivate you, they give you that feeling that it has already happened so maybe you can have a positive outlook about it."

### Socio-Emotional Mentoring and the Impact on Student Success

These smaller scale actions might include the care that faculty put into establishing relationships with their students that lead students to feel more confident reaching out for necessary support and guidance. Underrepresented students often enter college feeling apprehensive about approaching faculty and asking questions for reasons that may be associated with impostor phenomenon (Clance and Imes, 1987). However, WAESO-LSAMP environments were effective in diminishing this fear and led to students feeling more confident to reach out for help when needed. "What I learned is that when you need help, ask the instructor. Don't be scared. It's going to prepare me for college. I feel like I'm gonna struggle a little bit and I'd be afraid to ask the instructor for help [prior to Summer Bridge]."

Faculty are aware of the importance of fostering this type of socio-emotional growth in their students and some even believe it to be more of a priority than the academic programming that they provide. I had an in-depth conversation with two faculty mentors at one of the campuses. These faculty were both involved with Summer Bridge and one was a frequent sponsor of individual student research projects. While this excerpt is lengthy, it is important to share because of how they articulate very clearly their role in fostering confidence and self-efficacy, rather than reinforcing negative stereotypes that often follow underrepresented students through the educational pipeline. It is also reflective of the many conversations I had with WAESO-LSAMP faculty across the three campuses.

Mentor: What I've found is that students who come in and test underprepared or first-gen students or any kind of non-traditional student, the problem 90% of the time is not academic. It's one of learning the rules and one of confidence...of academia . . . Because that's not their language. And so, that's why we do what we do. Because that's, it's not an easy fix. But for too long, we've just focused on, "Oh academics, academics." And that's not what it is. So we spend a lot of time building up confidence . . . the students are here like all month. So it gives us a lot of time to like help build that confidence. . ..get to know them . . . Over the course of like a week or two, or about 2 weeks into it, by time we hit say July, students are much more comfortable. They'll come here. They'll hang out. (Faculty Mentor 1) is less scary, you know, all those things . . . And because of this and because of our attitude toward them, that's really what we're looking at. Our success rate is always in the 90th percentile . . . And we don't lower standards . . . and when those, you know, bottom levels of Maslow's hierarchy are served then they can open up to the learning.

I added emphasis to the statement, "and we don't lower standards" because often, programs that target underrepresented students are accused of either only selecting already high performing students or lowering standards so that their program appears successful. It was made very clear by all faculty involved in WAESO-LSAMP that they do not lower their standards or expectations for these students. They are adamant that their success is not based on choosing only high-performers (they recruit from schools with low transfer rates and include students who were not the highest academic performers.) And their student's work results in multiple conference presentations and presentations that win awards. Their students transfer, and enter the private sector where they are successful.

### Embracing Failure on the Path to Success

Part of the message that faculty are also adamant about–as mentioned above and reiterated from another faculty member below–is the importance of embracing failure and struggle in order to be successful. The emphasis on this as a central component of WAESO-LSAMP sponsored teaching seems to have had a profound impact on students and it is intentional.

Faculty: Science is tons of failure. That's all science is . . . So they have to learn how to fail...I think it's super important to fail...We are sitting down and talking like colleagues now. We are not teacher/mentor anymore and that change is huge and that only comes from failure. (emphasis added) If it happened the first time every time it wouldn't mean as much I think. So the struggle of maybe 5 weeks of failure and then all the sudden this giant success. It's huge.

It was interesting to see how excited these experienced professors were about the prospect and process of failing. These individuals are in their career because of years of objective success and the ability to navigate challenging and competitive environments. Based on my conversations with them, I found that teaching how to fail upwards, to embrace failure as an important part of academic growth and accomplishment, is central to their work with WAESO-LSAMP students. This helps students reframe their own struggles and challenges in a way that promotes growth, curiosity, and excitement rather than deters them from pursuing their goals because they feel like they are not good enough. By working through failure, they are becoming part of the community that they wish to join.

You can ask (mentor). . .I was so curious. [The experiment failed.] And, I was pretty excited for that. But that excitement I want to hold on to . . . I want to keep getting that excited when I figure something out or something goes wrong and I have to figure something out . . . That was what helped us most . . . There were a lot of times that I made a mistake, but the best part was [mentor.]

Faculty here effectively teach students that a failed lab experiment is not a reflection of the potential or worth of the student in the lab. Instead, they reiterate how important failure is in the scientific process. It becomes a critical lesson and learning experience for the student which results in a mindset that allows for non-linear paths to success as students grow beyond their first failed experiments. This helps students develop critical resilience and the confidence to troubleshoot, which contributes to students seeing "mistakes" as an exciting aspect of the scientific process, resulting in greater creativity and growth (Hochanadel and Finamore, 2015; Revelo and Baber, 2018; Beals, 2019) rather than as an individual failure.

## The Mentoring Chain–The Value of Integrating Peer-To-Peer Support

It is clear that intensive mentoring by faculty positively impacts the student-faculty relationship and student growth. However, my work with students also suggests that it also results in the organic development of a community of support. In my conversations with both students and faculty, the impact of peer-to-peer interaction and support emerged as a unique and effective strategy that faculty applied–whether directly or not. We refer to this phenomenon as "The Mentoring Chain," which consisted of a faculty mentor who led the team of students, who also mentored each other inside and outside the lab environment. This was often an intentional process from faculty, who would work with students for more than one summer and then put them into a leadership role with newer recruits. This type of environment encouraged students to lean on each other for support and encouragement, creating an environment of collaboration rather than competition. "It's easy for a student to ask another student a question. It's hard for a student to ask a teacher a question."

### Growing Through Mentoring Others

Students mentioned finding themselves mimic the type of mentoring they received from their WAESO-LSAMP mentors when working with their less-experienced peers. This not only helps the students learn proper lab techniques, but also gives them the opportunity to develop confidence in their own abilities and develop important leadership skills.

I approached it just like (mentor] showed me how to do it . . . It kind of gave me experiences . . . I would go to the students and tell them "Make sure you do this, make sure you do that". . .But then after the third week we started doing everything together. It was fantastic.

Some student mentors had opportunities to mentor high school students and give presentations about the paths available to them in higher education. This allowed students the opportunity to develop their own mentoring skills and also engage with students who shared similar experiences and backgrounds in a way that promoted a community of support and guidance throughout the entire transfer pipeline. Students reported feeling that peer mentorship was a rewarding experience.

You get a bunch of different opportunities (from WAESO-LSAMP). And then at the time I was tutoring at a high school . . . [We] presented there at the high school too. Yeah kind of like show the different paths that you could take . . . You would have people at the community college go and talk to people, or students at like a high school. And then as you transition from the community college to a 4-years university then you could mentor the people that were at the community college as a student at the university . . . I did the Summer Bridge program and now we get to help the new incoming students . . . we are their guiders technically.

## The Varied Approaches to Mentoring Communities

Conversations with student and faculty participants revealed that peer-to-peer mentoring took many forms. However, the most frequent aspects mentioned by participants included the opportunity to take a leadership role in teaching other students how to do technical STEM skills that they had learned from their mentor, including tips and tricks that a student learned in the past that they can now transmit to the newer student. Beyond this technical learning, students also practiced the same type of support and development of soft skills with each other that faculty found important. This included frequent checking in on each other's well-being, encouraging team members when things were challenging, collaborating to reach a common goal, and celebrating individual and group accomplishments. This influences students to see STEM education environments as collaborative with shared accomplishments rather than overly competitive.

[Peer Mentors] definitely helped. I would say [Student 1] took the lead, and he really showed me how to do things. He was very helpful as well. I feel like, by the end, we were on top of things. If I couldn't be there, then [Student 2] would be there. If [Student 2] couldn't be there, me and [Student 1] were there. We all would just like have each other's back.

Overall, mentoring in WAESO-LSAMP is a long-term, integrative process that begins at the time of recruitment. Faculty desire that the mentoring relationship evolve organically and know that the process of how students get involved with a mentor in the program is an integral first step. Students feel honored to be singled out but are often apprehensive about their skills. Faculty use non-traditional indicators of student potential, beyond GPA, and are in turn dedicated to serving their student recruits holistically. Faculty show a great deal of excitement toward their work in WAESO-LSAMP sponsored research, and in turn get students excited about the work while encouraging students to develop individual interests related to the work.

Mentoring then involves a great deal of professional and academic development. These might include the more direct or traditional things a mentor would help the student navigate, including various forms of professional networking, exposure to the academic world, and opportunities to engage in academia. Alongside this traditional mentoring, faculty engage with students in a way that transcends technical skill development. This work might include the less obvious roles that an effective WAESO-LSAMP mentor might play. This is where a student will develop soft skills necessary for successful college completion and academic life, easing the transition from high school to college largely by being a point of contact when the student officially arrives on campus, and carefully considering the unique needs of underrepresented students.

## Non-Technical Skills as Essential to Academic Success

The development of soft-skills, or other non-technical lessons, was discussed by faculty mentors and students alike. It is through the development of soft skills that students learn important qualities associated with being successful in the lab, the classroom, and in life working in STEM. Faculty mentors pass on important, non-curriculum information like time management, how to engage with professors, and how to navigate higher education in general. Here, a faculty mentor discusses the importance of this component of WAESO-LSAMP programming.

Besides the content of the actual class, themselves? Just how to prepare, how to successfully navigate a college class, whether it's learning how to come to office hours, how to contact the instructor if you're going be late, stuff like that. Just, things that are going to make you successful, being on time, attendance, having stuff done. College instructors don't give a lot of, "well, can you just bring it tomorrow?" That sort of thing, so, just getting them in that mindset of - it's a whole different level. It's like going from college athletes to pros.

This type of mentoring and support also helped students as they transitioned from high school to a college environment, or from the community college to a 4-years college and university. WAESO-LSAMP mentors are acutely aware of how important this type of engagement is for the students that they serve, often first-generation college students with little family support on how to navigate college campuses and transferring. One student spoke specifically about how having this type of mentorship made the Summer Bridge program especially meaningful and engaging rather than just a "get in, get out" summer class where she received class credit, but a starting place for a community that she had where she could find support whenever she ran into issues or had questions at her campus.

Having a point of contact for students transitioning into college was important because they knew where to go first when in need of help during their first semester. This is particularly important for students from underrepresented backgrounds, and faculty mentors take great care in making sure they are there to support these students and their needs as they prepare for and transition to the college environment. Faculty mentors frequently mentioned the unique position of non-traditional and low-income students and how their needs may differ from the needs of traditional students and their experiences. When probed about what faculty who work with underrepresented students should keep in mind when working with their students, mentors noted the importance of being understanding, empathetic, and a resource for these students and how this support network is an intentional aspect of WAESO-LSAMP program environments.

Students and faculty both mention several important traits of a quality mentor, including being empathetic, understanding, dedicated, and caring. However, quality mentors also help students identify aspects of impostor phenomenon while encouraging them to embrace failure as an exciting aspect of academic life, not one that signals lack of fit. Faculty mentors need to have compassion and empathy to greet students with positivity when they make mistakes rather than signaling a fatal flaw on the part of the student. This transfers into real-world success, independence, and self-efficacy. It is important to note that this process–while successful–is seen as less cost-effective and efficient than traditional mentoring, but yields what faculty see as great success.

## Embedding Social Capital Through Intensive Mentoring

Beyond feeling more prepared for college, WAESO-LSAMP students frequently mentioned the benefits of being connected with various social networks and building their social capital. Students specifically mentioned the benefits of being connected to faculty early and the impact it had on their relationships, work ethic, and their academic success, which they feel contributed to their positive experience within the program. As discussed prior, this intentional mentoring has a tremendous impact on students. However, it became clear that through working with WAESO-LSAMP faculty, students found that they were in general more connected to the campus and felt like they belonged when they saw their former mentor in their new, non-WAESO-LSAMP environment. "After (mentor] taught us . . . there was a gap and I needed to take [a class that] was taught by a different teacher. But during that time, I was in [science club], so [former Mentor] hung out in the lab...She knew us."

### Interpersonal Support as a Means to Other Opportunities

This interpersonal support positively impacted their academics and students report continuing to use those connections to identify other resources and be successful outside of WAESO-LSAMP sponsored environments on campus. Students were positively impacted by faculty, staff, and teachers that contributed to their positive academic experience. They have also continued to use these individuals as important resources as they navigate college. Students frequently mentioned that when things got difficult for them, "I would talk to (mentor] and then the coworkers I had here, since they had already taken multiple classes or the same class. I'd be like, "What did you do?" And ask for advice. That really helped." Some students also mentioned that this interpersonal support contributed to their inclusion into the campus culture and community, while still having caring, supportive, and empathetic teachers.

I think it was maybe like the shift from being like a like a high school student. Everybody's (WAESO-LSAMP] like, you know checking on you and just like making sure that you're okay. Especially like I said when they describe that to you in college, they're [high school teachers] like, "You're on your own. Nobody's going to ask you anything. You've got to figure everything out yourself." And [WAESO-LSAMP teacher] was like, looking at my grades was like, "Hey, come here. Did you make sure you get this in?" I was like, "Oh my God, thank God for you." Like it's still he's got like, that teachering thing, but it still gives you like independence also.

Overall, students found their WAESO-LSAMP experiences to be better or more beneficial than anticipated, easier than they expected, and much more accessible than they had been led to believe from their high school experiences. The formal and informal mentoring chains, access and exposure to college classrooms and environments, and the development of important skills led the students to feel prepared for college, comfortable on their campus, and with a mentoring chain to activate when things started to become confusing or challenging.

Interpersonal support from both peers and faculty also contributed to students having a more positive experience with the Summer Bridge program than they originally expected. Respondents utilized these connections continually in their future academic ventures, which also contributed to some students re-thinking prior plans as a result of their experience in the Summer Bridge and committing to stay at their respective campus.

At first, I actually didn't want to come to (current campus). I was like, "I wake up to it every morning. I want to go somewhere different." But then [Summer Bridge Director] came to our school and talked about the program and then I did the program and I just ended up staying because I liked it and then how I had someone that I knew could help me, not just for that summer, but for when I was actually here. It was very helpful because I was overwhelmed with college.

Students often mentioned that the connections that they made with their WAESO-LSAMP peers positively impacted their academic experiences and outlooks while also providing them skills to navigate the collegiate environment. This seems to stem from the collaborative network of peers, or a cohort effect, that develops after students engage with each other, from similar backgrounds, over a period of time. "It makes us united and then you have friends around campus which is very good. Helpful." Another student echoed this sentiment, and described specifically how recognizing that they had a shared background with their peers and the realization that they were on an equal level with them created a sense of a community that results in a network of support even after WAESO-LSAMP activities conclude.

It was cool because you got to ask them about how it was, or to see like, okay, we're taking the same levels. It was just cool because you got to meet them and experience everything with them and you got to keep those friends and possibly see them in other classes as well and just keep in touch because "I know we made friends during the summer that are still our friends and we still take classes with them."

Intensive mentoring, the development of formal and informal social support systems, college preparation, and the impact on academic growth result in increased engagement amongst WAESO-LSAMP students at their respective colleges and in their future plans. Regarding engagement, students primarily discussed how WAESO-LSAMP environments impacted their own academic and professional goals through the creation of a collaborative and mutually supportive environment of peers and advisors. This engagement had a positive impact on the development of self-efficacy, a commitment to academic goals, and feelings of empowerment to reach desired goals, especially in terms of challenging the impostor phenomenon and fears of failure.

# CONCLUSION AND IMPLICATIONS FOR PRACTITIONERS

WAESO-LSAMP programs have similar goals in extending their students opportunities to engage in hands-on, high level research with faculty mentors and influence feelings of belonging on campus. Summer Bridge focuses on preparing students for their first semester of college in terms of practical skills like time management and scheduling, but also focuses intensely on creating an experience where students develop confidence and self-efficacy to be successful college students.

Overall findings suggest that WAESO-LSAMP activities positively impact community college students in terms of self-efficacy. Students frequently mentioned having more confidence in their ability to transfer to a 4-years college, obtain a bachelor's degree, and advance toward graduate education. They also developed more confidence in terms of reaching out to and working with professors and navigating the social and physical environment of college. Being exposed to a community of peers and supportive faculty was a significant part of this growth in confidence. This has implications for literature regarding the importance and impact of developing a growth mindset, and how academic environments can foster this important aspect of resilience and success for underrepresented students (See also Banda and Flowers, 2017; Revelo and Baber, 2018; Beals 2019).

Students noted that WAESO-LSAMP activities positively impacted them in terms of finding themselves as part of a supportive community of students who had similar backgrounds as well as faculty who were ready and willing to work with them and make them feel like they belonged at their respective campus. Students expressed gratitude regarding the familiarization of the college environment and college life. These participants (often first-generation college students from low-income backgrounds and students of color) became familiar with campus activities through the WAESO-LSAMP Summer Bridge and developed an understanding of the institutional culture and climate of higher education. This helped them establish a sense of community for actual and prospective students alike, in that they get to know faculty, staff, and other students who they can reach out to for encouragement and support.

Program leaders mention that one of their primary goals is to expose students to the campus environment to show them that they have what it takes to be successful, demystifying this environment. Students concur, and often speak about their increased confidence in being able to navigate the community college environment, STEM education, and bureaucratic processes such as locating and applying for financial aid.

This appears to have a positive impact on student's likelihood of enrolling and persisting in their studies at a community college campus, although future follow up studies would need be to be conducted in order to assess whether or not this was the case once it came time to enroll. Some WAESO-LSAMP activities that certainly showed promise in supporting these objectives and impacting the academic and professional development of students include hands-on research with faculty and opportunities to attend training sessions and academic conferences, which are important for students' professional development and for seeing themselves as a member of the academic community in which they strive to be included. Opportunities for one-on-one interactions with faculty mentors along with ones for networking and peer-mentoring other students was also frequently cited by students as benefits of being a WAESO-LSAMP student. Faculty mentoring taught not just technical skills in STEM research, but also focused on fostering confidence, self-efficacy, challenging the impostor phenomenon, and learning to fail effectively.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available due to issues of privacy and confidentiality. Requests regarding this should be directed to Rebecca Beals, rebecca.beals@unco.edu.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of New Mexico IRB Maricopa County Community College District, IRB. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

RB is considered the first author of this paper and was responsible for the design, data collection, analysis, and structuring of the paper. SZ, FL, and OB contributed equally to literature review, idea sharing, and assisting with writing and referencing as last authors.

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# Georgia State University Perimeter College LSAMP Transfer Bridge Program: A Path Forward for Broadening Participation in Stem

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Summer Bridge Programs are increasingly becoming a popular strategy for Colleges and Universities to retain more historically underrepresented minority students in Science, Technology, Engineering, and Mathematics (STEM) disciplines. Retaining students in STEM disciplines is a necessary first step in order to accomplish the ultimate goal of diversifying the STEM workforce to create innovative solutions for today's complex problems. In this paper, the authors describe an exploratory and descriptive study of the promising Georgia State University Perimeter College (GSU-PC) Louis Stokes Alliance for Minority Participation (LSAMP) Transfer Bridge Program. Most summer bridge programs are designed to facilitate seamless entry into college for incoming first year students, but the GSU-PC LSAMP Transfer Bridge program is designed to support the successful transition of underrepresented STEM students transferring from a 2-year to 4-year institution. Early results indicate that the Transfer Bridge participants were significantly more likely to enroll in a 4-year STEM program, receive a STEM bachelor's degree, enroll in a post-baccalaureate STEM program, and receive a STEM post-baccalaureate degree than a comparison group of non-Transfer Bridge students at Georgia State University Perimeter College.

**Keywords: stem, summer bridge, transfer bridge, diversity, 2-year college, community college, retention**



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## INTRODUCTION

The growing challenge for the United States to lead in science and technology innovation is a driving force for increasing Diversity in Science, Technology, Engineering, and Math (STEM) disciplines (NRC, 2007; NRC, 2011). The projected job demand in these disciplines enormously outpaces the increases in diversity in STEM disciplines (Mason, 2016). Hence all higher education institutions must address this issue, and 2-year institutions and community colleges are key contributors. In fact, 2-year institutions and community colleges have a long history of playing a significant role in broadening participation for populations historically underrepresented in the STEM workforce including African Americans/Black, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, and Native Pacific Islanders. There are a number of publications highlighting the accessibility, affordability, and flexibility of 2-year institutions for underrepresented groups, first-generation, low-income, and non-traditional students to enter STEM disciplines and majors (Cohen, Brawer, and Kisker, 2014). Also, there are a number of publications emphasizing the critical role of community colleges and 2-year institutions in strengthening and expanding the STEM pipeline because of their diverse student populations (NRC, 2012).

Retaining students in the STEM disciplines is vital in diversifying the STEM workforce, and student engagement in summer bridge programs, faculty-mentored research, peer mentoring, group-study, professional development, and research/professional conferences are some high impact activities that correlate with successful student outcomes in STEM disciplines (Maton et al., 2012). These student engagement activities along with other student-focused strategies and approaches are hallmarks in the Louis Stokes Alliance for Minority Participation (LSAMP) Model Elements: STEM Academic Integration, STEM Social Integration, and STEM Professionalization (Clewell et al., 2006). The LSAMP Model integrates the Tinto Model of student retention (academic and social integration) (Tinto, 1975) by engaging students in STEM discipline activities so that they become familiar with their field of study or "Disciplinary Socialization" [a term coined by Bowman and Stage (2002) describing the STEM professionalization element of the model]. The LSAMP program has been successful in significantly increasing the quantity and quality of underrepresented students completing STEM degrees and pursuing graduate degrees in STEM disciplines (Clewell et al., 2006).

Summer bridge programs are one student retention and success strategy that can be designed to employ all three elements of the LSAMP Model. Increasingly, the STEM higher education community are implementing "Bridge" programs to address attrition, Increase graduation, and Encourage graduate education in STEM disciplines (Ashley et al., 2017). According to Michael Ashley et al. (2017), the majority (93%) of STEM bridge programs they reviewed targeted incoming first-year students and only 7% (2 of 30 programs) targeted incoming transfer students. They also found that 50% of the STEM bridge programs supported underrepresented minority students in STEM (Ashley et al., 2017). There are standalone STEM summer bridge programs and ones that are embedded in broader STEM intervention strategies and programs. With the latter model, students have continuous academic, social, and professional support after completing the summer bridge program. An example of a published STEM intervention that embeds a summer bridge program within their model is the University of Maryland Baltimore County's Meyerhoff Scholars Program. Their bridge program targets incoming first year students (Hrabowski and Maton, 1995; Summers and Hraboswski, 2006; Maton et al., 2012).

In this article, we describe the program and research study for the Transfer Summer Bridge Program (Transfer Bridge) that has been implemented at Georgia State University Perimeter College (GSU-PC) since 2009. GSU-PC is the only 2-year partner institution in the Peach State LSAMP and is the major provider of associate degrees and student-transfer opportunities in Georgia. It is a gateway to higher education, easing students' entry into 4-year colleges with an Online College and five campuses in the metro-Atlanta area. The Transfer Bridge is a specialized summer bridge program designed to create successful 2- to 4-year transitions for transfer students majoring in STEM disciplines. Most summer bridge programs are designed to facilitate seamless entry into college, but the GSU-PC LSAMP Transfer Bridge program prepares their STEM students for a seamless transfer from 2-year institutions and successful completion of a bachelor's degree at a 4-year institution. Students participate in the Transfer Bridge after they have enrolled at GSU-PC for at least one semester, as opposed to immediately after finishing high school prior to first-time enrollment as a college student. The Transfer Bridge program demonstrates the importance and effective practices of transfer partnerships. There is a growing consensus that student success is more likely when the 2-year institution actively supports the student and the transfer process and the receiving 4-year institution actively takes responsibility for the student's academic success after the transfer (Finks and Jenkins, 2017).

## MATERIALS AND METHODS

### GSU-PC Transfer Bridge Program Methods

Georgia State University Perimeter College hosts a rigorous Transfer Bridge program each year in the month of May under the leadership of Professor Margaret Major. The program is a 3 week student-focused, faculty-mentored research training and engagement program. The Transfer Bridge program was designed for GSU-PC LSAMP scholars who have been enrolled at the commuter college full-time for at least one semester prior to the Transfer Bridge program. The primary goals of the Transfer Bridge project are to increase the number of Peach State LSAMP scholars transferring to 4-year Peach State Alliance (and other) colleges and universities and to increase the likelihood they will persist and graduate with a baccalaureate degree in a STEM discipline. The intensive 3-week program not only equips students with comprehensive research techniques and skills used to solve scientific problems, but also introduces them to STEM in industry, cutting-edge research conducted at research institutions, life at a 4-year college as a STEM student, as well as step-by-step processes for transfer admission requirements and acquiring financial aid.

The Transfer Bridge Program supports all three elements of the LSAMP model—STEM academic integration, STEM social integration, and STEM professionalization. Its core high impact activities include mentorship, research training and engagement, partner-facilitated visits to 4-year institutions, and STEM industry tours. See **Table 1** below.

### Mentorship

Faculty- and peer-mentoring are key strategies in promoting student academic (both undergraduate and graduate) and career success in STEM disciplines (Hill et al., 2010; NRC, 2011). Research has shown that quality time with a mentor significantly impacts student success for STEM students engaged in undergraduate research (Pita et al., 2013). GSU-PC Transfer Bridge includes formal mentor-mentee and mentoring networks for its participating LSAMP students. The Transfer

**TABLE 1** | Transfer bridge high impact student engagement.

| **Transfer bridge student engagement activities** | |
|---|---|
| Mentorship | Small groups of students participate in a learning community lead by a faculty member |
| Research experience | Students work directly with faculty members on a "mini" research project for 3 weeks and give a poster or oral presentation of findings |
| Four-year college visits | Day-long campus visits consist of faculty- or graduate student-led research lab tours as well as engaging interaction with financial aid staff, transfer admissions staff, Peach State LSAMP scholars, and STEM faculty and graduate students conducting research in the students' areas of interest at those institutions |
| STEM industry tours | Students engage with scientist and engineers in behind-the-scene tours at STEM-related manufacturing and research and development facilities |

Bridge mentoring activities include the following methods and mentoring models:

- **Faculty mentoring**–Faculty meet with students daily to guide, monitor progress, advise, provide support, answer questions, and address concerns about research problems and processes.
- **Peer mentoring**–Transfer Bridge students major in a range of STEM disciplines and provide guidance, tutoring, and advice as student leaders for their peers. Depending on the type of problem being addressed, a student may take on the role of mentor and possibly the reverse in which she may take on the role of mentee throughout the 3-week program.
- **Mentoring Network**–Faculty and Student-learning communities work together on multidisciplinary scientific problems. Integrated teams have either one or more STEM faculty and up to four students to work collaboratively on a specified research project. Hence the students develop lasting relationships with mentoring networks of both peer- and faculty-mentors.

## Research Experience

The Transfer Bridge research experiences provide real-world research projects with faculty mentors in order to build foundational research skills for the Transfer Bridge students. The research training and engagement is accomplished using "mini" research projects that can be accomplished in 3 weeks. Research experience is intended to excite and encourage the Transfer Bridge students to persist in their STEM fields. Through hands-on research engagement, the students acquire the following skills: 1) Ability to conduct a literature search and develop a hypothesis, 2) Ability to conduct research design and statistical/analytical methods, 3) Ability to present data in oral and written formats, and 4) Knowledge of laboratory safety and ethical issues in science. The faculty mentors also assist the students in identifying and applying for summer internships at major research universities.

The specific objective of the research experience is to provide STEM students at 2-year colleges an engaging interaction with a faculty-led research project that they may not typically have at a 2-year institution. The Transfer Bridge students are totally immersed in developing and implementing a scientific investigation while reviewing scientific literature based on the project they are assigned. Throughout the Transfer Bridge program, the students are required to maintain a legal, scientific research notebook and to conduct controlled research projects, including the reporting and analysis of data. Transfer Bridge students work both independently on research projects and collaboratively throughout the 3 weeks on a poster and PowerPoint presentation. At the Transfer Bridge closing program, each research team gives an oral presentation on its research investigation. Sample research projects are listed in **Table 2**.

## Four-Year College Visits

Visiting 4-year institutions is a key strategy of support that enables successful 2-year to 4-year transitions. Day trips to one or two Peach State LSAMP senior institutions are taken during the Transfer Bridge program. The visit is jointly planned by the 2- and 4-year institutions. In order to prepare for the visit, Transfer Bridge students are provided a full agenda for the day and campus information, such as admissions and financial aid electronic links, prior to the visit. In addition, the 4-year partner institution arranges for one of their senior LSAMP scholars to serve as the tour guide for the entire visit, which kicks off with an opening session and welcome from the LSAMP Co-PI and or Director.

A typical visit includes meetings with financial aid and transfer admissions staff, two or three STEM research lab tours, lunch with the LSAMP Director from the 4-year institution, and an interactive "student-lead" session with a panel of the 4-year LSAMP students. Financial aid personnel provide the Transfer Bridge students with information regarding the financial aid process and deadlines and special scholarships that are available to STEM students. Admissions representatives discuss the transfer admissions procedures, transfer hours, GPA requirements, and application and file completion deadlines. During the research lab tours, the Transfer Bridge students engage with cutting-edge technology and faculty, researchers, and both graduate and undergraduate students. The visit ends with a candid discussion with a panel of LSAMP students representing a diverse mix of STEM disciplines from the 4-year institution. The Transfer Bridge students gain meaningful information about the Classes, Student Life, Personal Experiences, and Campus Culture.

## STEM Industry Tours

The industry tours offer Transfer Bridge students an opportunity to see exciting STEM processes and applications while engaging with Scientists, Researchers, Engineers, and Project Managers. The students learn about innovative ideas and witness problem-

**TABLE 2 |** Sample GSU-PC transfer bridge research projects.

| Sample transfer bridge research projects | Research teams |
|---|---|
| Verification of pGreen map in transformed *Escherichia coli* | 4 GSU-PC Faculty and 3 Transfer Bridge Students |
| Determination of sugar content in sodas | 2 GSU-PC Faculty and 4 Transfer Bridge Students |
| Electrochemistry and battery technology | 2 GSU-PC Faculty and 3 Transfer Bridge Students |
| Investigating the effects of environmental noise on bird songs, part 3–a continuing comparison of different bird species | 1 GSU-PC Faculty and 3 Transfer Bridge Students |
| Environmental factors affecting spore germination of sensitive fern (*Onoclea senibilis*) | 2 GSU-PC Faculty and 3 Transfer Bridge Students |

**TABLE 3 |** Typical GSU-PC transfer bridge daily activities–Microbiology research project.

| Week | Day | Work |
|---|---|---|
| 0 | Wednesday | • Mandatory orientation<br>• Introduction to project |
| 1 | Monday | • Select samples and who is responsible for collecting them<br>• Practice Gram staining from pre-cultured TSA. |
| | Tuesday | • Prepare samples (for grinding, add 5 ml of sterile water to 250 g of food)<br>• Inoculate ONPG-MUG tests (100 ml of water directly for water samples; for food samples use 5 ml of supernatant to 95 ml sterile water)<br>• Serial dilutions and plating of 100 µl for dilutions $10^{0}$ (100 µl directly from water sample or food supernatant), $10^{-01}$ (1 ml of water/supernatant to 9 ml of sterile water), $10^{-02}$ (1 ml of water/supernatant to 9 ml of sterile water) on EMB plates. Store plates at 37°C, read at 24/48 h |
| | Wednesday | • Record serial dilution/plate count results for 24 h<br>• Record ONPG-MUG coliform test for 24 h |
| | Thursday | • Record serial dilution/plate count results for 48 h<br>• Record ONPG-MUG coliform test for 48 h<br>• Spread plate selected ONPG-MUG samples (two from each sample, 16 samples = 32 plates) for isolation of individual colonies on EMB.<br>• Work on PowerPoint and poster |
| | Friday | • Tour: Oak Ridge National Laboratory |
| 2 | Monday | • Inoculate TSB for antibiotic sensitivity testing from EMB plates (16 colonies)<br>• Inoculate TSA slants for Gram staining from EMB plates (16 colonies)<br>• Work on PowerPoint and poster |
| | Tuesday | • Inoculate MHA agar for antibiotic sensitivity testing from TSB.<br>• Perform gram stains<br>• Work on PowerPoint and poster |
| | Wednesday | • Record antibiotic sensitivity testing results for 24 h<br>• Perform Gram stains<br>• Work on PowerPoint and poster |
| | Thursday | • Record antibiotic sensitivity testing results for 48 h<br>• Work on PowerPoint and poster |
| | Friday | • University of Georgia Research Lab Tours |
| 3 | Monday | • Memorial day |
| | Tuesday | • Work on PowerPoint and poster<br>• Practice presentation |
| | Wednesday | • Work on PowerPoint and poster<br>• Practice presentation |
| | Thursday | • Work on PowerPoint and poster<br>• Practice presentation |
| | Friday | • Transfer Bridge Closing Program Oral Presentations |

solving approaches in action. These experiences demonstrate the value of their foundational core technology and math and science classes while inspiring them to finish their STEM degree. Seeing the industry processes along with one-to-one conversations with STEM professionals promote understanding and often introduce them to career pathways that they did not know exist. Typical STEM Industry Tours include Automobile and Aircraft Manufacturing Plants, Food-Processing Manufacturing Plants, Textile Manufacturing Plants, Battery Research and Development Facilities, Department of Energy National Laboratories, Technology Design Facilities, Waste-Water Treatment Plants, and Marine Science and Fishery Facilities.

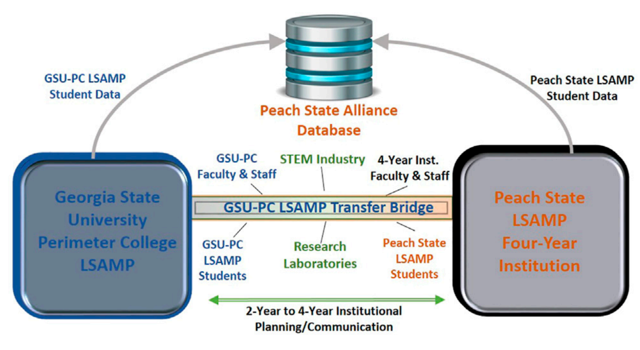


**FIGURE 1 |** Ideal GSU-PC transfer bridge process.

## Student Recruitment and Selection

GSU-PC LSAMP scholars are eligible to participate in the Transfer Bridge Program. In order to be a LSAMP scholar, the student must have at least a 2.7 GPA, be enrolled full-time in a STEM discipline at GSU-PC, and have less than 70 credit hours. In addition, students must be a member of an underrepresented population in STEM as specified by the grant funder, including American-Indian, Alaskan-Native, African-American, Hispanic/Latino, or Native Hawaiian or other Pacific Islander. The GSU-PC LSAMP Campus Coordinators recruit students for participation in the Transfer Bridge program by marketing the opportunity, and students self-select to apply.

## Implementation Details

The Transfer Bridge Program is hosted on one or more of the GSU-PC commuter campuses immediately following the spring semester. There are typically a cohort of 8–12 participants to engage with four or more faculty for three intense weeks of collaborative learning, research investigation and laboratory work, and field trips. The students are subdivided into smaller teams to work on faculty-led research problems. The type of research project dictates the specific daily activities, but each participant is required to work in the lab or the field each day (Monday–Friday) for a minimum of 4 hours. Most of the students tend to work on their research projects 8 hours or more per day. The field trip days include tours to STEM corporations and visits to Peach State LSAMP 4-year college campuses as described earlier. **Table 3** describes the daily tasks.

The typical costs for the Transfer Bridge program include pay for faculty, stipends for students ($500–$1,000 per student), research materials and supplies, and travel costs for field trips and campus visits. The travel costs vary depending on whether the trips require overnight stays in hotels and per diem costs. It is important to plan the research projects well in advanced to ensure that needed materials and supplies are available and committed faculty-mentors are available to lead the research activities.

## Concurrent Interventions

The Transfer Bridge students are GSU-PC LSAMP scholars, so each participant has engaged in the LSAMP programming for at least one semester. The GSU-PC LSAMP programming includes the following:

- Academic Advisement
- Professional Development Workshops
- Scientific Seminars and Technology Talks
- Service Learning Projects (7 h/semester)
- Academic Support (Tutoring, STEM Labs, Drop-In Centers, Group Study)
- Alumni Panels/Seminars
- Peach State LSAMP STEM Innovators Conference
- Student Networking Events
- Access to Research and Internship Opportunities
- Student Stipends

Ideally, the Transfer Bridge students can choose to transfer to the one of the Peach State Alliance 4-year institutions. So if they do, they will be integrated into the LSAMP program at the transfer institution. **Figure 1** depicts the "ideal" Transfer Bridge Process with follow up and concurrent LSAMP engagement for the students. When a Transfer Bridge student enrolls at a Peach State LSAMP 4-year institution, their data in the Peach State Alliance Database is updated such that the transfer institution will become the owner of the student data and continue to update the student's file (LSAMP activities, mentors, student progress) until their graduation.

## Research Methods

To better understand the success of the GSU-PC Transfer Bridge Program in supporting the Peach State LSAMP's goal to extend the STEM pipeline, the Alliance research team led by Dr. Karen DeMeester conducted an exploratory and descriptive study of the program. The research study examined the rates of Transfer Bridge Program participants' 1) enrollment in 4-year institutions, 2) pursuit of STEM degrees at 4-year institutions, 3) attainment of undergraduate degrees in STEM disciplines, and 4) enrollment in graduate degree programs in STEM-related disciplines. We also examined enrollment and degree attainment in general as well as STEM-specific disciplines. The Transfer Bridge participants' outcomes were compared to a group of GSU-PC students who were eligible for participation in Transfer Bridge but who did not participate in the program. The study is an exploratory and descriptive study that employed a comparison group to provide context and to improve understanding of program outcomes. The use of secondary data, however, did not enable us to control completely for differences amongst our groups, and therefore results of the study are not generalizable and do not evidence impact. To obtain additional context, we also surveyed Transfer Bridge participants to learn what aspects of the program they perceived as most beneficial and supportive of persistence in college completion in general and achieving college degrees in STEM fields specifically.

### Data Collection

A data sharing agreement was executed between the University System of Georgia (USG) and the University of Georgia, and a request for enrollment, degree award, and demographic data for Transfer Bridge participants and a comparison group of GSU-PC students was submitted to USG's Research and Policy Analysis department. The Peach State LSAMP Director and the Transfer Bridge Program Director compiled the names and student identification numbers of all students who participated in Transfer Bridge from its first year in 2009 through 2019. Due to COVID-19 restrictions, the program was altered and conducted virtually in summer 2020. The Peach State LSAMP Director submitted the student information to USG through its secure file transfer system. Through the same secure transfer system, USG provided research analysts at UGA's Carl Vinson of Institute of Government de-identified data (stripped of names and identification numbers) for the Transfer Bridge participants along with a comparison sample of GSU-PC students that met the eligibility requirements for participating in Transfer Bridge but did not participate in the program. To participate in Transfer Bridge, a student had to be from a historically underrepresented population in STEM, United States. citizen or resident alien, and enrolled full-time in an associate-level degree in STEM at GSU-PC. The research analysts compiled and analyzed the data and only reported results at an aggregate level. The program Directors who submitted the list of students including the names and identification numbers did not have access to the data received from USG, and the research analysts that received the data from USG did not have access to the list of participant names and identification numbers submitted to USG. The USG data are limited to public institutions within Georgia and do not, therefore, include data on students' enrollment and degree attainment in private institutions in Georgia (e.g., Emory, Morehouse, and Mercer universities) or any institutions outside of Georgia.

To triangulate and supplement the USG data results, Transfer Bridge participants from 2009–2018 were invited to participate in a survey to 1) track their post-program enrollment in bachelor's and post-bachelor's degrees, degree completion, and areas of study; 2) track their post-program participation in research; and 3) gain insight into participants' perceptions of how Transfer Bridge influenced their academic persistence, especially in STEM. The survey was administered through the Qualtrics survey platform, and Transfer Bridge alumni responded to the survey from April 15, 2019 through May 9, 2019.

### Sample

The USG data set yielded data for a sample of 85 Transfer Bridge students and 71,301 non-Transfer Bridge students. Overall, students included in the sample were primarily Black or African American (71.9%), and there was no significant difference in race/ethnicity, high school GPA, or first-generation status between Transfer Bridge and Non-Transfer Bridge participants. Students in both samples were predominantly citizens (89.1%); however, the Transfer Bridge sample had a significantly higher proportion of resident aliens (43.5%) than the non-Transfer Bridge sample (10.8%). Proportionally, there were significantly more males participating in Transfer Bridge (50.6%) than in the non-Transfer Bridge group (38.7%).

### Analysis

We used SPSS to perform chi-square tests on the USG student data to examine statistically significant differences in the rates of enrollment and degree completion for Transfer Bridge and non-Transfer Bridge participants. For the Transfer Bridge alumni survey, we used SPSS to calculate frequencies and means, and we analyzed open-ended comments for patterns and emergent themes.

# RESULTS

## Results of University System of Georgia Data

Results of our analyses showed statistically significant differences for outcomes related specifically to STEM enrollment and degree completion. As **Table 4** shows, Transfer Bridge participants were significantly more likely to enroll in a 4-year STEM program, receive a STEM Bachelor's degree, enroll in a post-baccalaureate STEM program, and receive a STEM post-baccalaureate degree than non-Transfer Bridge students. There were no significant differences between Transfer Bridge and Non-Transfer Bridge students for non-STEM specific enrollment or completion of non-STEM degrees (bachelor's or post-baccalaureate). The only demographic differences found were that Transfer Bridge students were more likely to be resident aliens and males than the non-Transfer Bridge students. High School GPA was close to being significantly different but remained just above the 0.05 threshold.

Results should be interpreted with caution, however, because all significant results had small expected cell counts. The expected count for STEM bachelor's enrollment among Transfer Bridge students was *just* less than 5 (4.2 students), while the expected counts in the other outcomes for Transfer Bridge students ranged from 0.1 to 1.3. This is likely due to both the relatively small number of Transfer Bridge students (85 compared to the 71,301 non-Transfer Bridge students) and that STEM enrollment/degree receipt were relatively uncommon events for the non-Transfer Bridge students. Since the larger group engaged in these STEM events at such a small rate, it created small marginal percentages resulting in small expected cell counts in the smaller group. Analyses where cell counts were less than five were for dichotomous outcome variables and, therefore, were not able to be further consolidated into categories to address small expected cell counts. Again, given the small expected cell counts, these results should be interpreted with caution.

## Results of Transfer Bridge Alumni Survey

### Summary

Forty-three alumni of the Transfer Bridge Program responded to the survey from April 15, 2019 through May 9, 2019. **Figure 2** shows the number of alumni who responded from each cohort year. The majority of respondents (58%) participated in Transfer Bridge during the last 5 years. Sixty-five percent (65%) of the alumni (28) who responded to the follow-up survey reported being currently enrolled in an institute of higher education while 35 percent (15) said they were not currently enrolled in school. **Table 5** shows the information for the 28 alumni currently enrolled, including the year they participated in Transfer Bridge, the institutions

**TABLE 4 |** Results from USG data analyses.

| Outcome | Non-Transfer bridge | | Transfer bridge | | Total | | Chi-square | Sig |
|---|---|---|---|---|---|---|---|---|
| | *N* | % | *N* | % | *N* | % | | |
| Enrolled in a non-STEM Bachelor's Program | 12,442 | 17.4 | 14 | 16.5 | 12,456 | 17.4 | 0.057 | 0.812 |
| Enrolled in a STEM Bachelor's Program | 3,483 | 4.9 | 45 | 52.9 | 3,528 | 4.9 | 417.347 | 0.000[a,b] |
| Conferred a non-STEM Bachelor's Degree | 5,432 | 7.6 | 4 | 4.7 | 5,436 | 7.6 | 1.024 | 0.312 |
| Conferred a STEM Bachelor's Degree | 1,083 | 1.5 | 29 | 34.1 | 1,112 | 1.6 | 588.342 | 0.000[a,b] |
| Enrolled in a non-STEM Post-Bachelor's Program | 713 | 1.0 | 2 | 2.4 | 715 | 1.0 | 1.567 | 0.211[b,c] |
| Enrolled in a STEM Post-Bachelor's Program | 93 | 0.1 | 4 | 4.7 | 97 | 0.1 | 130.979 | 0.000[a,b,c] |
| Conferred a non-STEM Post-Bachelor's Degree | 373 | 0.5 | 0 | 0.0 | 373 | 0.5 | 0.447 | 0.504[b,c] |
| Conferred a STEM Post-Bachelor's Degree | 41 | 0.1 | 3 | 3.5 | 44 | 0.1 | 166.137 | 0.000[a,b,c] |

[a]*The Chi-square statistic is significant at the .05 level.*
[b]*More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.*
[c]*The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.*

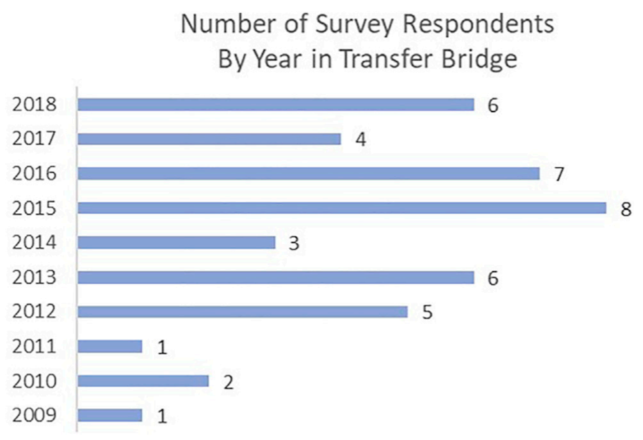


**FIGURE 2 |** Number of survey respondents by year in transfer bridge program.

where they are enrolled, degrees they are pursuing, and their area of study/major. The information presented is from alumni who participated in Transfer Bridge program from 2011 to 2018. All 15 respondents who are not currently enrolled in higher education reported having already graduated. Of the 15, three provided no additional information while the other 12 provided the information presented in **Table 6**. Of the 12, nine indicated they intend to apply to graduate or professional programs in the future.

Overall, Transfer Bridge alumni commented that their experiences in the program contributed to their persistence in STEM education and pursuit of STEM careers. Specific experiences mentioned were opportunities to apply principles learned in the classroom, learn programming, work in a research lab, attend conferences, and network with mentors and professionals in the field. When asked what aspects of the program had the greatest influence on their Academic Careers, Alumni mentioned Research Experiences, Mentorship and opportunities to engage with faculty and advisers, visits to 4-year institutions, and support with recommendations. Alumni concluded that the most influential elements of the program on STEM persistence were exposure to new STEM areas of study and career fields, opportunity to use and gain experience with lab equipment and techniques, increased understanding of what specific disciplines and fields they wanted to pursue, increased confidence to pursue education and careers in research, increased competencies and skills (e.g., time management, work ethic) needed to succeed in advanced education, and increased interest in STEM research, education, and careers.

## Full Results

Transfer Bridge Alumni were asked if any of their experiences in the program contributed to their persistence in obtaining their degrees, comments include the following:

- My current position at my job is because of what I did during the Summer Bridge Project I did back in (GSU-PC).
- The Transfer/Summer Bridge Program allowed the practical application of principles learned, during lectures and labs, to relatable experiences, which influenced my decision to pursue/obtain multiple STEM degrees.
- Inspired me to pursue a career in Engineering.
- Transfer/Summer Bridge Program introduced me to programming which emphasized my desire to become a Software Engineer.
- Mentoring
- My research experience from working in the Research Lab, Attending Conferences and Networking with Mentors and Professionals in the field contributed to my desire to obtaining a STEM-related degree.
- The summer Bridge Program greatly helped me in pursuing a STEM career
- Yes
- It definitely did. I was able to define my future goals and narrow down my path
- (GSU-PC) Transfer/Summer Bridge Program provided me coaching/mentoring and research experience that helped me throughout my undergrad program.

Alumni not currently in an educational program were asked what influenced their decision not to continue their education at

**TABLE 5 |** Information from Transfer Bridge Alumni Currently Enrolled in.

| Institution | Degree | Area of study |
|---|---|---|
| University of Michigan | Doctoral/Ph.D | Mechanical Engineering |
| Lake Erie School of Osteopathic Medicine | Doctoral/Ph.D | Pharmacy |
| Georgetown University School of Medicine | Professional | Doctor of Medicine (MD) |
| Georgia Institute of Technology | Masters | Electrical Energy and Telecommunications |
| Massachusetts Institute of Technology | Doctoral/Ph.D | Biology (focus in Structural Biology) |
| The Geisel School of Medicine at Dartmouth | Doctoral/Ph.D | Not chosen a specialty yet, but considering Neurosurgery or Neurology |
| Lake Erie School of Osteopathic Medicine | Professional | Pharmacy |
| Georgia Institute of Technology | Bachelor's | Computer Science |
| Kennesaw State University | Bachelor's | Mechanical Engineering |
| Georgia Southern University | Master's | Pharmacogenomics and Translational/Precision Medicine |
| Georgia Institute of Technology | Doctoral/Ph.D | Electrical Engineering |
| University of Pittsburgh | Professional | Dental Medicine |
| Georgia Institute of Technology | Bachelor's | Chemical and Bio-molecular Engineering |
| Georgia Institute of Technology | Bachelor's | Electrical Engineering |
| Georgia Institute of Technology | Bachelor's | Civil Engineering |
| Georgia Institute of Technology | Bachelor's | Electrical Engineering |
| Georgia Institute of Technology | Bachelor's | Chemical and Bio-molecular Engineering |
| Manchester University | Professional | Pharmacy |
| Georgia Institute of Technology | Bachelor's | Computer Science |
| Kennesaw State University | Bachelor's | Civil Engineering |
| Georgia Institute of Technology | Bachelor's | Electrical Engineering |
| Georgia Institute of Technology | Bachelor's | Industrial Engineering |
| Georgia State University | Associates | Biology |
| Georgia State University | Associates | Biology |
| Georgia State University | Bachelor's | Computer Science |
| Georgia State University | Bachelor's | Biology |
| Mercer University | Bachelor's | Mechanical Engineering |
| Georgia State University | Doctoral/Ph.D | Biology |

**TABLE 6 |** Information from transfer bridge program alumni who graduated and are not currently enrolled in higher education.

| Institution | Area of degree | Do you plan to enroll in a graduate or professional degree program? | Intended area of study |
|---|---|---|---|
| University of Georgia | Dual Bachelors in Microbiology and Biological Science | No | |
| Georgia Institute of Technology | Biochemistry | No | |
| University of Georgia | Environmental Health | Yes | Pharmacy |
| Georgia Institute of Technology | Electrical Engineering | Yes | Electrical Engineering |
| Georgia State University- Perimeter College | Biology | Yes | Doctor of Pharmacy |
| Georgia Institute of Technology | Mechanical Engineering | Yes | IT |
| Kennesaw State University | Computer Science | Yes | Management |
| University of Georgia | Biochemistry and Molecular Biology | Yes | Doctorate in Pharmacy (Drug therapy and development) |
| Georgia Institute of Technology | Electrical and Computer Engineering | Yes | PhD in Control Systems Engineering |
| Georgia Institute of Technology | Computer Engineering | Yes | Computer Science |
| Georgia Institute of Technology | Mechanical Engineering | No | |
| University of Southern California | Mechanical/Petroleum Engineering | Yes | Petroleum Engineering |

this time, four of the respondents presented in **Table 6** provided the following comments:

- There are a lot of Good Opportunities in my field with a Bachelor's degree. I want to gain industry experience to find out what I want to pursue and decide whether I want to pursue a graduate degree.
- Personal decision (i.e., age, family, career field), and the fact, additional education would not influence promotion potential, in my current career field.
- Ongoing continuing Ed for current job is sufficient
- I am planning to work for 2 years and come back to school to get my masters.

A goal of the Transfer Bridge Program is to encourage and prepare students to participate in additional research training experiences and to do additional work in a research laboratory setting. Transfer Bridge Alumni were asked whether or not they had participated in additional research training since completing the Transfer Bridge Program. Sixteen Alumni responded to this item. Of the 16, only five indicated they had participated in additional research training. Three of the five provided the following descriptions:

- Currently taking research methods in college for Computer Science.
- I learned about Robotic Operating System, some controls, Linux Operating System, Robot Setups and Demo, and ESM usage.
- I participated in a Research Experience for Undergraduates at Lehigh University in Pennsylvania during summer 2016 right after my Summer Bridge Experience. Participating in the Summer Bridge before my REU prepared me for my REU experience.

Alumni were also asked if they had worked in a research lab since participating in Transfer Bridge. Fifteen respondents answered this survey item: Eight respondents reported not having worked in a research lab while seven reported they had additional lab experience. Of those that said "Yes," four described his/her experience. The comments are as follows:

- Currently I work in a research lab. We work on Battery Technology and Electrochemistry. I've been introduced to different types of machinery. I've learned Data Analysis through these machines. I've also been able to apply the things I've learned during the Summer Bridge Program and in my courses.
- Georgia Tech Robotics Department; Boston University Mechanical Engineering Department
- I was working as a lab assistant in one of my Professor's lab last semester, and it changed my mind about going to graduate school. I am now definitely going to graduate school. Research and Lab experiences are eye-opening for me and many other students.
- Worked as a Research Assistant in inputting data from surveys taken from a specific population which studied mainly the patterns of bike riders.

Alumni were asked how their experiences in Transfer Bridge influenced their academic careers. Overall, the most influential outcomes of the program were exposure to new STEM areas of study and career fields, opportunity to use and gain experience with Lab Equipment and Techniques, increased understanding of what specific disciplines and fields they wanted to pursue, increased confidence to pursue education and careers in research, increased competencies and skills (e.g., Time Management, Work Ethic) needed to succeed in advanced education, and increased interest in STEM research, education, and careers. Thirty-Two of the 43 survey respondents (74%) provided the following comments:

- Helped me to get exposure with a PLC device.
- It helped me maintain and formulate a structure as well as Time Management Skills. It has also helped in the research course I am currently taking.
- It gave me exposure to academic research.
- I have learned the importance of doing undergraduate research not only for my resume but for life in general. I learned how to use many things in a lab that I will be working with for the last 2 years of my bachelor's degree.
- It was a Tremendous Benefit to have some kind of technical experience after my first year in college. It really helped me in my application for a DHS summer internship program. If I didn't have that opportunity I don't know if I would have enough to talk about in my application. I enjoyed the program so much that I changed my major to something more related to the project.
- The Transfer/Summer Bridge Program reinforced work ethics, which allowed me to graduate Cum Laude, with Dual-STEM Bachelor Degrees.
- I had an opportunity to experience what a research program is like. It helped me get over some anxiety that I felt in regards to research.
- It exposed me to a cutting edge research field in the area of renewable energy. I had the opportunity of working on Piezoelectricity which helped me in transferring to Georgia Tech and further strengthen my passion for Renewable Energy.
- It exposed me to the research field that I greatly appreciate.
- My experience in the Georgia State University-Perimeter College Transfer/Summer Bridge Program influenced my academic career in a lot of ways. It helped me to choose what I want to do in my career life. I wanted to study in the STEM field but I wasn't sure what I wanted to study. Summer Bridge Program helped me to pursue my career in Chemical Engineering. I am always grateful for getting that chance.
- It Showed me that you don't have to be a doctor to be successful. If being a doctor doesn't work there are a Million of other jobs in a STEM field.
- It was my first experience working in a lab. It gave me confidence that I can learn to work in a lab and feel comfortable in research settings.
- Research experience, Working in Teams, and Interest in STEM
- The Summer Bridge program exposed me to research and that made me more interested in Public Health
- It helped me to see that research is not for me so I decided to Pursue Medicine.
- It helped me significantly in getting the First-Hand Experience of what research entailed and What it required.
- Transfer/Summer Bridge introduced me to Programming Language (C++) which helped me succeed in the Programming Courses I took afterward.
- Perseverance to get through Tough Courses
- It was nice to have mentors that I could talk to about my Future Plans. People who cared about my success.
- During the Summer Bridge Program I developed a lot of skills that I didn't learn in my classes and that increased my interest in Electrical Engineering
- It made me more interested in pursuing a STEM related major and Furthering my Education to Graduate Level Degrees.

- My Experience in the Summer Bridge Program greatly influenced my Academic Career. I learned how to carry out a Short Research Project with a team. In addition, I learned how to think more critically about Scientific Experiments, Analyze Scientific Data, and Present my data at meetings. Without this program, I would not have pursued additional research experiences and most likely wouldn't have ended up at MIT for my PhD in Biology.
- The Research Experience I had and the results I obtained during the Summer Bridge Program allowed me to better fit into New Lab Groups and Excel. It made it easier to conduct undergraduate research during regular semesters in the school I transferred to which is essential for my graduate school application. I'd say the Georgia State University-Perimeter College Transfer/Summer Bridge Program initiated my interest in graduate school.
- It made me realize how exciting research is and that I wanted to pursue more of it.
- It made me more aware of the opportunities in the STEM field and informed me of ways to achieve them through the workshops and tours of STEM industries. Being part of the program brought me closer to peers who had the same interest and created the avenue to study together, work on projects and put our minds together.
- It gave me Great Experience and Increased My Desire
- My Experience helped me obtain a Bachelors in Biotechnology. Also in my current career path, my experiences have helped me. I gained skills that are applicable in various aspects of healthcare
- It Influenced my Career Choice
- Participating in the Summer Bridge Program helped influence my Academic Career. I was able to get an Internship through this program.
- The Summer-Bridge Program positively shaped my career in numerous ways. It gave me an opportunity to pursue scientific research for the first time, under the mentorship of great and wonderful scientists and mentors. It influenced my decision to transfer to a research-focused 4-year college (Emory University). Through these same opportunities, I continued to pursue my research interests and even founded a non-profit to provide similar research opportunities for young women in Ghana and Nigeria who are interested in pursuing STEM careers. After graduation from Emory, I did an NIH research fellowship for 2 years at Mount Sinai in New York before matriculating into medical school. While in medical school, I am still actively involved in research and will be doing a summer research fellowship at the NIH Neurosurgery Department. What started off as an 8 weeks summer research program has influenced the kind of physician I want to be.
- The Bridge Program was crucial in rendering my application competitive in both Undergraduate and Medical School. Also, it's important for me to underlie that, as an undergraduate, Perimeter College was the only school, where I had the opportunity to do research and apply the theories I learned in class in a laboratory setting. I loved the experience. This is why, as a medical student, I am leaning more toward a field that requires more research, Neurosurgery.
- The Research Experience was the biggest influence that I received from this program. The opportunity to work with researchers from GA tech helped me in my studies.

Transfer Bridge Alumni were also asked what aspects/components of the program had the greatest influence on their Academic Careers. The same alumni who responded to the question about the program's influence on their academic careers also provided comments about what aspects of the program were most impactful for them. Overall, Research Experiences, Mentorship and Opportunities to engage with faculty and Advisers, visits to 4-year institutions, and support with recommendations. Their comments are as follows:

- My Relationship with my mentor and the kind of project I was involved in, my STEM industry tours all contributed a big role.
- All parts had a huge impact but the research experience was the best because it helped me explore something I might be passionate about
- The Tours and College visits were instrumental for me to figure out how to use Academic and Non-Academic Resources in order to succeed in school and life afterward.
- My Relationship with my research advisor was great because she wrote me many recommendations for other research opportunities for this summer.
- The Part of the program that had the biggest impact was the mentorship from the professors. They gave me real responsibility and expected results, which really pushed me to learn. I especially enjoyed being able to present my research at the ACM Southeast conference where I was able to practice my public speaking skills. It was a great networking opportunity and gave me invaluable experience.
- No particular part of the program, had more of an impact, over the others. Each impacted my life in different ways.
- I learned more about Collecting Data, Writing a Report, and Giving a Presentation. I wish there were more computer science related projects. Because I felt many of them were focused on fields related to Biology or Chemistry instead of Technology. But the experience overall was great.
- All of it. Mentors believed in me and helped guide me, research gave insights on renewable energy, college visits helped with making a choice on major and passion, tours exposed me to Life as an Engineer.
- The Research Experience
- Research Experience, Relationships to Mentor.
- The Research Experience and Tour of STEM Industries.
- I Really enjoyed the mentoring. They help you plot out an academic evaluation to see which classes would best be put together. Since I had to double up on my Science Classes.
- Having Hands on experience with processes of research and learning how to work with a professor.

- Visits to Colleges and Universities, Research Experience, and Mentor
- Relationship with Mentors and Working in Groups made the most impact, as well as Oral and Poster Presentation
- Tour of Stem Universities had the Greatest Impact
- The Greatest Area of Impact was the Invaluable Experience I got from the research.
- I think every part of program had the greatest impact on me because there is always an opportunity to learn new things.
- All
- I would say visits to Colleges and Universities. It motivated me to apply a 4 years University.
- My Relationship with my Mentor, Gedeon helped me a lot when I transferred to Georgia Institute of Technology.
- There were two parts of the program that greatly impacted me which are the research experience and visit to Colleges and Universities.
- Research Experience overall (with my Mentors and Peers).
- The Greatest Impact for me I would say was the research project I was working on and my relationship with my advisor really. Those two parts increased my interest in Academic Research and Graduate School.
- The Research Experience.
- The Research Experience had the greatest impact because it exposed me to numerous opportunities that allowed me to gain lab experience, grow and also learn in the STEM field. Through it, I was able to obtain leadership skills, think independently, and work efficiently with diverse teams. In all, it was an experience I would always be grateful to have been part of.
- Research Experience.
- The research itself was a great experience, but the tours helped me shape my career path. Each tour gave me exposure to different STEM careers and I was able to see first-hand what each path has to offer.
- Tour of STEM industries, visit to Colleges and Relationship with Mentor.
- The visit to UGA had the greatest impact because we got to see UGA's Research Labs. It helped me understand that I wanted to do research in terms of my field. Also by going to UGA I was able to meet a faculty who forwarded my Resume, and thus provided me with an Internship.
- Our visits to Colleges and Presentations at conferences were the most impactful. It gave me an insight into 4 years colleges and ways I can continue to do research after transferring. Moreover, having the opportunity to present my summer work to peers and mentors was critical in my growth as a young scientist. It gave me the confidence I needed to continue to pursue a career in science. I had a wonderful relationship with my research mentor during the summer bridge program, and she continues to support me in all my career endeavors.
- My relationship with my mentor was amazing. In fact, we are still in contact till now. Also, the research experience was enjoyable and challenging at the same time. I enjoyed the fact that I was waking up every morning to go do what I love. I would give anything to be part of it again.
- Research Experience had the Greatest Impact.

## Limitations

A key limitation of the study was the limited sample size of Transfer Bridge participants. A total of only 114 students have participated in the Transfer Bridge Program (2009–2018), and of those, we were only able to obtain data for 85 (75%). In addition, we were unable to obtain data (e.g., National Student Clearinghouse Student Tracker Data) on participants who enrolled and graduated from Institutions outside of the University System of Georgia, including private institutions within the state (e.g., Emory) as well as Institutions outside of Georgia. While the alumni survey provided some of the data, we realize that response bias potentially exists with self-report data. Furthermore, those alumni who chose to respond to the survey could be more likely to represent those with positive outcomes (successful STEM degree enrollment and graduation) than those who chose not to respond. It is likely that Transfer Bridge participants were already predisposed to be successful. Transfer Bridge participants had to already be a member of the Peach State LSAMP program at GSU-PC and then self-select into the supplemental Transfer Bridge summer program. To participate in Peach State LSAMP, students already had to be high performing academically and motivated. There were no significant differences, however, between Transfer Bridge and Non-Transfer Bridge participants in high school GPA.

Another limitation was the USG data did not specify major for GSU-PC associate degrees. As a result, we were not able to limit the non-Transfer Bridge comparison group to just those students enrolled in a STEM-focused major. It is plausible that the comparison group contained a number of students who were not interested in STEM or pursuing STEM areas of study and were, therefore, less likely to pursue future STEM education.

# DISCUSSION

## Outcomes and Implications

The GSU-PC Transfer Bridge Program aims to increase the number of Peach State LSAMP scholars who transfer to 4-year Peach State Alliance (and other) Colleges and Universities and to increase the likelihood that they persist and graduate with a baccalaureate degree in a STEM discipline. The program employs key strategies for supporting student success and persistence in STEM, including mentorship, opportunities to gain research experience, visits to 4-year Colleges and Universities, and tours of STEM industries. We conducted a preliminary exploratory and descriptive study to examine the relationship between participation in the Transfer Bridge Program and higher rates of 1) Enrollment in 4-year institutions, 2) Pursuit of STEM degrees at 4-year institutions, 3) Attainment of Undergraduate Degrees and Undergraduate Degrees in STEM Disciplines, and 4) Enrollment in Graduate Degree Programs and STEM-related graduate degree programs. University System of Georgia Enrollment, Degree Attainment, and Demographic Data were obtained, and the data set yielded a sample of 85 Transfer Bridge

Students (75% of all students who participated in the program from its inception) and a comparison sample of 71,301 GSU-PC students who met the minimum eligibility criteria to participate in the Transfer Bridge Program but who chose not to participate. Chi-Square Tests were used to examine statistically significant differences in rates of Enrollment and Attainment of Baccalaureate and Post-Baccalaureate Degrees for the Transfer Bridge and Non-Transfer Bridge Participant Groups. Results of the analyses indicated that Transfer Bridge participants were significantly more likely to enroll in a 4-year STEM program, receive a STEM Bachelor's Degree, Enroll in a Post-Baccalaureate STEM program, and Receive a STEM Post-Baccalaureate Degree than non-Transfer Bridge Students.

To triangulate and supplement the USG data results, we invited Transfer Bridge participants from 2009–2018 to participate in a survey about the benefits of specific components of the program and the quality of implementation of those components. The majority of the alumni who responded to the survey (65%) reported being enrolled in an Institute of Higher Education. Half of those students were enrolled in bachelor's degree programs with a STEM major, and 43 percent were enrolled in post-baccalaureate programs with a STEM area of focus. When asked what, if any, aspects of the program influenced their persistence in STEM education, Alumni cited the Mentorship, Research Experiences, Opportunities to attend conferences and to network, and technical skills gained during the program. Alumni were also asked how their experiences in Transfer Bridge influenced their academic careers. Overall, the most influential aspects of the program were exposure to a variety of STEM disciplines and career fields; Opportunities to gain academic and Research Competencies, Skills, and Techniques; Clarity about what disciplines and fields they wanted to Pursue, and increased confidence to pursue education and careers in STEM.

Results of the Transfer Bridge study provide increased understanding of what outcomes are most critical for supporting the transfer of historically underrepresented students in STEM from 2-year to 4-year institutions and their successful completion of STEM degrees. Critical outcomes include basic research understanding and skills, confidence to engage with faculty mentors, sense of preparedness to participate in cutting-edge research, and increased awareness of STEM career pathways. Key components of a STEM bridge program targeting transfer students include research experiences, mentorship and opportunities to engage with faculty and advisers, and visits to 4-year institutions. In addition, this article provides detailed information for implementing the Transfer Bridge Program and its components. Programs interested in creating and implementing similar bridge programs may benefit from the detailed discussion of the logistics.

### Next Steps

To extend and improve on the preliminary results of this study, we will request USG data for a comparison group of just GSU-PC LSAMP students from 2009–2018 who chose not to participate in the Transfer Bridge Program. This more specific comparison group will enable us to examine differences in rates of STEM enrollment and degree attainment between groups of students who have all demonstrated an interest in pursuing STEM-specific education programs. Through this approach, we will also be able to examine whether there are statistically significant differences between LSAMP students who chose to participate in Transfer Bridge Program in addition to their regular LSAMP activities and those who did not chose to participate.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because This is confidential student data that must have the expressed permission from the University System of Georgia to share. Requests to access the datasets should be directed to Leslie Hodges, leslie.hodges@usg.edu.

## ETHICS STATEMENT

The study was submitted to the University of Georgia Institutional Review Board. Upon review of the application, the study was deemed exempt from meeting the requirements of the federal regulations for human subjects protections.

## AUTHOR CONTRIBUTIONS

AB, KD, and MM made a substantial, direct and intellectual contribution to the work, and approved it for publication. BS cleaned the proprietary student data, ran the data analysis, and interpreted the results and limitations.

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# Continued STEM Commitment in Light of 2020 Events: A Perspective From the Illinois Louis Stokes Alliance for Minority Participation

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We evaluated the impact of the current COVID-19 pandemic and systemic racism on Underrepresented Minority (URM) students pursuing higher education in the STEM fields. Given the ongoing pandemic and the wave of protests in response to a series of police brutalities and systemic racism, URM students were thrown into uncharted territory. We reached out to a group of Black and Latino students who were already engaged in STEM. We began surveys and interviews by asking participants how they were and how their family and communities were doing. Next, participants answered questions about academic progress, challenges, and what support would be helpful. Our framework was based on a mixed-methods approach that draws on the work of Michael Patton (Qualitative Research & Evaluation Methods: Integrating Theory and Practice, 2014) and Veronica Thomas (American Journal of Evaluation, 2016, 38 (1), 7–28). Qualitative data from interviews were collected to capture perceptions, experiences, and recommendations of the study participants. Survey data were collected to reach as many students as possible and to provide numerical self-assessments of student experience, progression, and obstacles. All qualitative data were coded thematically using Atlas. ti, with the goal of illuminating emerging themes, and quantitative data were reviewed using descriptive statistics. Themes emerging from both data sets were compared, contrasted, and integrated in order to develop consistent findings that would enhance URM student perseverance and persistence in the face of confounding adversities. This study shows that ILSAMP COVID-19 Study participants maintained a commitment to pursuing a career in STEM. The findings of this study also indicate that the participants are stressed by their immediate circumstances and by the ongoing racism of U.S. society. These students ask for additional financial, academic, and networking support during the disruptions caused by the pandemic. More specifically, students request continued advising and connection with STEM professionals who can help them envision and enact a pathway to their own careers in STEM during this tumultuous period. The study validates the importance of key elements of the national LSAMP model as reported by Clewell et al. (Revitalizing the Nation's Talent Pool in STEM, 2006). These are: academic integration, social integration, and professional integration. In addition, it identifies several other factors that are key to student success, including interventions that directly address racial trauma and economic hardship.

**Keywords: systemic racism, Lsamp, stem education, minority, underrepresented minority, COVID-19 pandemic, deconstruct URM**

# INTRODUCTION

In this introduction, we provide an overview of the study and a literature review. This is followed by three major sections: Methods, Results, and Discussion.

## Overview of the Study

This study set out to understand how underrepresented minority students pursuing higher education in the STEM fields have been affected by two significant events that unfolded in 2020: the COVID-19 pandemic and the wave of Black Lives Matter protests responding to the killing of George Floyd by Minneapolis police and, more broadly, to police brutality and systemic racism (Evans, et al., 2020; Krieger, 2020). The research, initiated in the spring of 2020, examined the experience of students in the face of these developments, how the experience affected their academic progress, what support they received, and what support they needed.

The first COVID-19 patient in the United States was diagnosed January 21. On March 13, the president declared the pandemic to be a national emergency. On March 26, the number of U.S. cases surpassed those in China and Italy. The United States became the most infected nation (USA Today, 2020), a ranking that it still holds as this article is drafted in 2021, with Black, Latino, and Indigenous communities getting sick and dying at rates that exposed and exacerbated the underlying racial inequalities in U.S. society. The nation's education system was profoundly disrupted.

This study was conceptualized by the Center for STEM Education and Research (CSER) and the Illinois Alliance for Minority Participation (ILSAMP) at Chicago State University (CSU), and it was implemented between July and September 2020 by a team of researchers affiliated with Creative Research & Evaluation LLC (CR and E). CSU is the lead institution for the ILSAMP and CSER is a hub for STEM activities on the CSU campus. ILSAMP is a 27-year-old alliance of 12 institutions of higher education from across the state of Illinois (https://www.csu.edu/ILSAMP), and it is part of a larger national group of similar alliances funded by the National Science Foundation (NSF). The alliance's central mission is to improve the retention, success, and progression of underrepresented minority (URM) college students in Science, Technology, Engineering, and Mathematics (STEM).

This study took place during a period when the COVID-19 pandemic had already killed at least 158,000 people in the United States. Black Americans and Latinos got sick with the virus at a higher rate, were hospitalized with it more often, and died from it more often than white Americans. Black Americans were hospitalized 4.7 times more often than white Americans, and Latino Americans were hospitalized 4.6 times more often than white Americans (The Center for Disease Control, 2020). Black and Latino families were also disproportionately losing income, going hungry, and facing evictions (Maxwell, 2020).

The study also took place in the wake of the events on and following May 25, when Minneapolis police killed George Floyd. A viral video showed him die while an officer knelt on his neck in the street. Black communities across the country responded with public marches and memorials. Led by Black Lives Matter activists, public attention turned to anti-Black police brutality and systemic racism, and the country was swept by a wave of Black Lives Matter protests (Buchanan et al., 2020). In order to understand the perceptions and the impacts of the pandemic and the wave of anti-Black violence and subsequent protests on the experiences of URM STEM students and their progression to graduation, we set out to answer the following research questions within the ILSAMP Alliance:

1. What is the experience of ILSAMP students and their families during the COVID-19 pandemic and the increased visibility of systemic racism?
2. What is the impact of these two current confounding events on the academic progression of ILSAMP students?
3. What support are students receiving from their institutions and the ILSAMP program?
4. What other supports do ILSAMP students need?

The participants in this study were drawn from all the undergraduate students who registered for the 2020 Spring Symposium in STEM, which was organized by CSER and Illinois LSAMP and held in late February. This annual symposium is a two-day event where STEM undergraduates from the 12 institutions in ILSAMP present their research, attend panel discussions with STEM professionals and graduate students, and interact informally with other students and professionals. Undergraduate participants include LSAMP scholars and other prospective scholars. LSAMP scholars receive stipends for conducting research and participating in other professional, social, and academic activities. By definition, all LSAMP scholars meet the NSF criteria for being an "underrepresented minority". Most of the other students who attend are also African American, Latinx, Indigenous, or multiracial. Every student who participated in the symposium received an email invitation to participate in the survey component of the study. A small number of students from every partner school were also invited to participate in one-on-one interviews.

## Literature Review

Prior evaluations of Illinois LSAMP showed that ILSAMP students are excited by opportunities to engage in research

**TABLE 1** | Major LSAMP components.

| Focus/Activity for students | STEM academic integration | STEM social integration | STEM proffesionalization |
|---|---|---|---|
| Summer Bridge | ✓ | ✓ | |
| Scholarship/Stipend | ✓ | | |
| Peer study Group | ✓ | ✓ | |
| Skills Building Seminar | ✓ | ✓ | |
| Learning Centers | ✓ | ✓ | |
| Academic Advising | ✓ | | |
| Summer Acedamic Enrichment | ✓ | | |
| Tutoring | ✓ | | |
| Research Experience | ✓ | ✓ | ✓ |
| Mentorships | ✓ | ✓ | ✓ |
| Conferences | ✓ | | ✓ |
| Internships | ✓ | ✓ | ✓ |
| Career Awareness | | | ✓ |
| GRE Test Preparation | ✓ | ✓ | ✓ |
| Graduate School Admissions Support | | | ✓ |
| Graduate summer Bridge | ✓ | | ✓ |

and are inspired by attending annual conferences with STEM students and scientists who look like them (Blanc and Day, 2020). In addition, the evaluation of ILSAMP during its prior 5-year funding period showed that both enrollment and graduation of under-represented minority (URM) students increased at participating universities. In 2013, 1,351 baccalaureates were awarded to URM STEM students at nine four-year institutions in ILSAMP. By 2017, the number had increased by 380 to 1,731. The approximate average increase of 7% per year surpassed the Alliance goal of an annual increase of 5%. In addition, the number of URM STEM baccalaureates increased at a slightly higher rate than White and Asian baccalaureates during the same period (op cit.). The evaluation findings that ILSAMP participants were enthusiastic about research activities and that the initiative was affecting graduation rates are consistent with a rigorous 2006 evaluation of the national LSAMP initiative, which indicated that LSAMP participants had more positive outcomes on a variety of measures than comparable students, including enrollment in post-baccalaureate STEM courses (Clewell et al., 2006).

Clewell et al. (2006) identified three key aspects of the LSAMP model across the entire portfolio: academic integration, social integration, and professional integration. Of particular importance is the fact that successful LSAMP partners address all of these aspects of student experience based on the needs and strengths of their particular campuses and communities. In their evaluation, the authors of the national LSAMP evaluation found that LSAMP as a whole reflects a theory of student retention developed by Vincent Tinto in the 1970s. Tinto hypothesized that a college is able to retain students through graduation only if these students become attached and committed to the college. This requires academic integration into the formal, institutional aspects of college (success in courses, knowledge of course progression, etc.) and social integration into the informal aspects of college life (faculty/staff interactions, extra-curricular activities, peer-group interactions, etc.) (**Table 1**) In addition, LSAMP incorporates a component of professionalism or socialization and induction into the sciences through activities and services that prepare students for the future and teach them the skills, culture, and attitudes of their prospective professional discipline and what it takes to be successful in STEM. De Cohen (2006) described professionalism as anchoring students to their disciplines while preparing them for the future.

As explained by Clewell et al. (2006) and Othman (2016), Tinto developed a theory of departure from college at a time when the field of higher education in the United States was expanding rapidly, but was also experiencing a large number of first-generation students who were leaving before attaining their degrees. Drawing on the theories of social anthropology (Van Gennep, 1960) and sociology (Durkheim and Simpson, 1951), Tinto developed a stage model to explain how first-generation students move through the process of leaving their families, transition to a new situation, and become incorporated into a new environment. Using this model, Tinto argued that withdrawal from college is the result of insufficient integration into the new community. A major implication of the Tinto model is that colleges and universities can take active steps to help students from all backgrounds become better integrated into the institutions. As discussed below, the Tinto model has been the object of frequent critiques and revisions. Nevertheless, it was an important guiding principle for many student support programs that began developing in the 1970s and 1980s. Clewell et al. (2006) identified a large set of activities that typified LSAMP programs and provided a review of empirical data for the success of these interventions. **Table 1** provides an overview of these activities.

Many researchers have critiqued the Tinto model and continue to develop and refine new theoretical paradigms. Although Tinto has refined his language and uses the term “belonging” rather than “integration” (Tinto 2015), his critics continue to fault a model that introduced the idea that successful students must experience a rupture with their families and be integrated into the dominant culture of universities. Among many examples of themes and research studies that contrast with Tinto’s initial assumptions about student integration into higher education are:

- Studies of Latino student experience by Sylvia Hurtado and her colleagues. These utilize large, longitudinal data sets and argue that researchers must pay attention to subjective student experience, including experiences of racism, in order to identify interventions that can change exclusionary institutional culture and structures (Hurtado et al., 1996).
- Ethnographic, longitudinal studies of varieties of science identities and how they change over time and interact with racial identity, often drawing on work of Carlone and Johnson (2007).
- Exploration of how universities can support belonging and take into account different identities, such as race, gender, and sexual orientation (Straythorne, 2018).
- Psycho-social quantitative studies that use frameworks such as Bandura's social cognitive theory to analyze how student agency and racial identity intersect with science self-efficacy (White, 2017).
- Financial analyses that demonstrate the importance of finances in supporting or inhibiting STEM graduation (Castleman et al., 2017).

To date, the authors have found few published research studies or peer-reviewed articles about LSAMP programs. Although formative and summative evaluation is required for all LSAMP programs, the authors have not yet identified theoretical or empirical research about LSAMP that utilize conceptual frameworks that provide alternatives to Tinto's theory of integration. This is somewhat surprising given that there are decades of work by researchers such as Hurtado (op cit.) and Carlone (op cit.) about how racial identity, science identity, and STEM success are intertwined for students of color. The gap in theoretical framing of LSAMP's success and challenges could usefully be filled in many ways, including examination of LSAMP as a programmatic framework for creating a community in which both racial identities and science identities are visible and valued.

The research reported in this article was developed and implemented very quickly in response to ia request about immediate needs of LSAMP students during the period of the COVID pandemic. In this context of crisis, the research team formulated an approach and design that drew on members' varied skills and experiences. Although the study was primarily practical and empirical—and was not designed to respond to issues raised in the literature—the team brought a depth of knowledge and experience, including personal and professional knowledge of Black and Latino families and communities, years of work with community-led racial justice groups, and extensive knowledge of LSAMP strategies and program components that derived from many years of implementing and evaluating the Alliance. Thus, though this study was not designed to speak to the research world, the results are likely to have relevance beyond the project's immediate sphere.

## METHODS

This section addresses the research framework and instruments, the process of participant recruitment, the study sample, and the processes for data analysis.

### Research Framework and Instruments

This research study drew on survey and interview data collected between July 20 and August 20, 2020. Analysis and initial reporting were completed prior to September 30, 2020. The research was designed to explore the experiences and center the voices of underrepresented minority students who had been enrolled in undergraduate STEM programs in ILSAMP institutions at the start of the COVID pandemic and to identify supports that would help ensure students' well-being and support their academic progress.

Given the extent of the crisis at the time the research took place, the team had no assumptions that participants would still be enrolled in school or thinking of themselves as STEM students. In addition to taking the usual steps in planning a research project, the team identified a process for helping participants access immediate support if it was needed. As we report below, most study participants were still in school and were not in the midst of serious crisis. However, the team's sense of responsibility to step out of their researcher roles in order to support participants is a reminder of the intensity of COVID-19 impacts during the summer of 2020. This sense of responsibility to participants was also evidence of the team's adoption of a commitment to a culturally responsive approach to research and evaluation.

Drawing on culturally responsive evaluation approaches articulated by scholars such as Veronica Thomas, the team aimed to be attentive to culture, context, and inclusiveness in all phases of the research, including design, data collection, analysis, and writing. The culturally responsive approach was integrated into the team's use of qualitative methods, as well as its use of survey data.

The principles of culturally sensitive evaluation produced by the American Evaluation Association (AEA) and described by Thomas and Parsons are applicable to this research project. The AEA called for fitting theory to the cultural context of evaluation practice, as well as engaging in a set of essential practices (e.g., recognizing the dynamics of power, recognizing and eliminating bias in language, employing culturally appropriate language, and acknowledging the complexity of cultural identity) (Thomas and Parsons, op cit. p. 9).

In this study, a culturally responsive approach led the team to foreground questions related to family, community, and racial experiences even though participants in the study were selected because they had been LSAMP students. As argued by researchers such as Hurtado and Carlone, family/community identities and student/scientist identities are frequent sources of tension in the lives of URM STEM students. As mentioned above, given the context in which the research took place, the team had no advance knowledge about participants' actual realities and whether they would even consider themselves STEM students at the time of the research.

Quantitative survey data were collected with a goal of reaching as many students as possible, and as a method to collect provide numerical self-assessments of student experience, progression, and obstacles. As with interview protocols, surveys were constructed with the goal of conveying a sense of respect, interest, and support for participants. Survey responses were

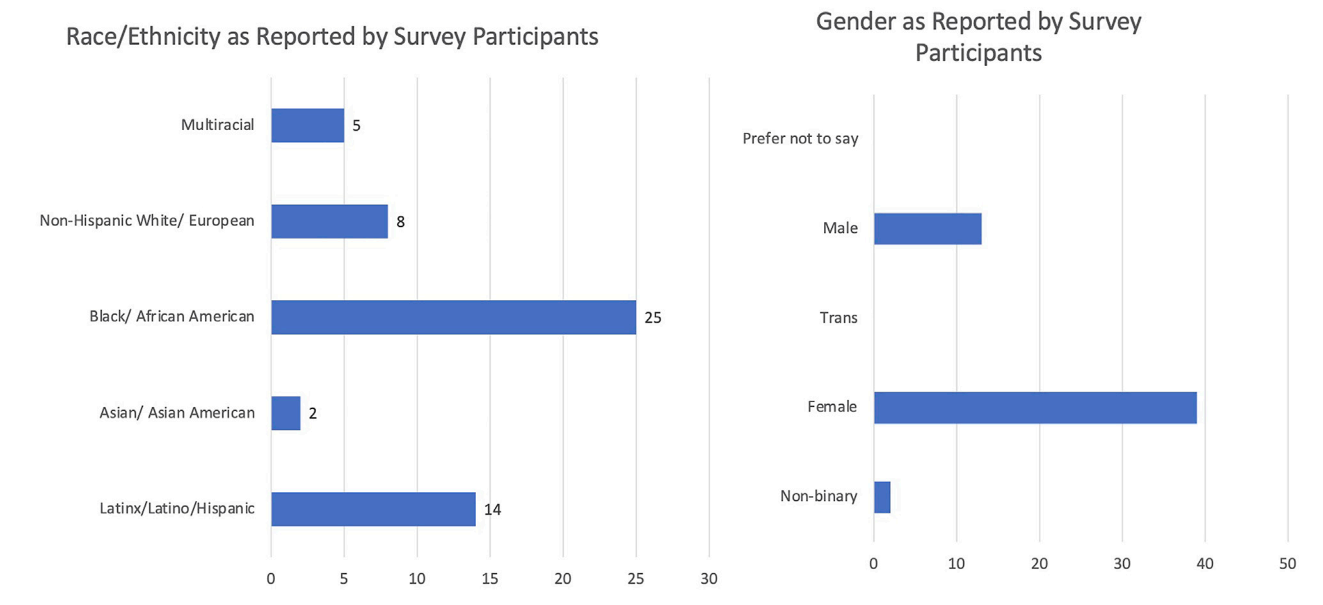


**FIGURE 1 |** Gender and race/ethnicity.

analyzed using descriptive statistics such as frequency distributions of responses, as well as measures of central tendency (mean, median, mode).

In his guide to qualitative evaluation and research, Michael Quinn Patton writes that qualitative methods are especially useful for documenting the diverse perceptions of participants in their own words and for producing findings that emerge from the fieldwork, not from the laboratory or the academy (Michael Quinn Patton, 2014). In this study, the use of interviews was especially appropriate to provide in-depth and detailed study of participant experiences without requiring detailed development of categories that would be used for analysis and reporting.

An important decision in developing instruments was beginning both the surveys and the interviews by asking participants how they were doing as people, as family members, and as members of communities. After answering questions about themselves and their families, they moved on to answer detailed questions about academic progress, academic challenges, and what other supports would be helpful. Understanding how URM students negotiate two of their identities that are typically challenging—their family/community identity and their academic identity—will be essential to creating an environment in the STEM fields where racial equality goes beyond lip service and where the contributions of people from communities that have previously been shut out are truly embraced.

The survey instrument was designed by the research team for online administration through the Survey Monkey platform. It consisted of 26 questions and was designed to be completed in 15–20 min. The first survey section had both closed-ended and open-ended questions about student and family experiences, supports, and hopes. The first question on the survey asked participants to rate their overall well-being and that of their families using a slider. The scale on the slider went from 0 on the left to 100 on the right. The scale was labeled in the following way: Zero on the scale was identified as "having problems", the midpoint (50) was identified as "OK," and 100 was identified as "fine." A follow-up survey question asked students to explain their numerical ratings. Based on answers to this question, the research team defined categories to provide a rough sense of where most students fell on the spectrum and to demonstrate the extent of variation in how students and their families were doing during the pandemic and the wave of protests.

The second survey section consisted of multi-part questions about students' academic progress, challenges, and expectations. These were primarily a checklist designed to capture information about students' academic pathways. Most of these questions also included a section where students could add open-ended responses. This section included a request for student recommendations on how ILSAMP could support its target population. The final section of the survey asked students to identify their colleges, majors, and year in college. They were also asked to self-identify their gender and race/ethnicity (**Figure 1**), with options to choose as many labels as they liked and to add their own descriptors. At the end of the survey, students had another opportunity to identify suggestions and add open-ended comments.

Semi-structured, open-ended interviews were designed to address many of the same themes as the surveys, with the opportunity for students to explore issues in more depth. In addition, the interview protocol specifically asked students whether they would like to share their perceptions and experiences on heightened national awareness of racist violence and recent Black-led protests. These interviews were structured as interactions that would be constructive alternatives to a long-embedded research practice in which white researchers are in positions of power while the people of color are not necessarily the agents in a research process. The three-person team implementing the research study consisted of one white member, one Black member, and one Latinx member. With one exception, all interviews were conducted by the two people of color on the team, who are researchers with extensive experience listening to and supporting young people in their communities. The interview was designed to take 30–45 min and to be conducted remotely, either by phone or by Zoom.

## Participant Recruitment

Another important initial decision was to draw our sample from the mailing list of students who had participated in the 2020 Spring Symposium in STEM, organized by CSER and the Illinois Louis Stokes Alliance for Minority Participation (ILSAMP). Thus, we reached a group of Black and Latino students who had already been relatively engaged with STEM. The Symposium was held in late February 2020, shortly before all universities and college ended in-person classes. Thus participants were recruited from a group of young people who are already likely to be interested in careers in STEM and who had been motivated to take advantage of opportunities to conduct research and to interact with other STEM scientists and professionals who look like them.

The annual symposium is a two-day event where STEM undergraduates from the 13 schools in ILSAMP present their research, attend panel discussions with STEM professionals and graduate students, and interact informally with other students and professionals. Undergraduate participants include LSAMP scholars and other undergraduate STEM students. LSAMP scholars receive stipends for conducting research and participating in other professional, social, and academic activities. By definition, all LSAMP scholars meet the NSF criteria for being an "underrepresented minority". The great majority of other students who attend the Symposium are also African American, Latinx, Indigenous, or multiracial and are also involved in activities sponsored by LSAMP or other similar programs on their campuses (Blanc and Day, 2020). Although they are not LSAMP scholars, these students are also considered LSAMP students because they also attended at one or more LSAMP events (i.e., the Symposium and possibly other LSAMP activities). The option to participate in the survey was shared with all undergraduate students who registered for the 2020 Spring Symposium in STEM.

All participating undergraduates in the spring symposium received an email in early August 2020, explaining the study and inviting them to participate in an anonymous online survey. A subset of students was also invited to participate in the interview study. The list of survey invitees was developed to ensure that representation from every college that participated in the symposium was included in the interviews. Invitations for students from each college were roughly proportional to each college's participation in the symposium. When information was available, the initial group of those invited from each college was randomly drawn from a list of students who had received LSAMP scholarships in 2019–20. If this information was not available, the interview invitees were randomly drawn from the list of students registered for the symposium from each college. The study followed informed consent protocols as approved by the Chicago State University IRB. As an incentive, survey participants had the opportunity to participate in a drawing for a $50 gift card. As an incentive and as a recognition of the value of their time, all interview participants received a $25 gift card.

## Study Sample

The study sample was a self-selected group of STEM students from a larger Universe of students who participated in the 2020 Spring Symposium in STEM. Out of 166 symposium registrants, 78 started the survey, 54 completed it, and 24 interviews were conducted.

Of the survey respondents, 44 were from underrepresented minority groups in STEM, as defined by the National Science Foundation. Ten survey respondents were from groups that are not considered underrepresented in STEM. The survey was completed by students who identified in the following ways: 25 African American students, 14 Latino students, 5 multiracial students, 8 white students, and two Asian students. All multiracial students identified themselves as African American and another race; Latino and another race; or Pacific Islander/Hawaiian and another race. Twenty-one of the interviewees were from underrepresented minority groups in STEM as defined by the NSF. Undergraduate students from 11 ILSAMP partner colleges and universities participated in the research. These will be referred to here as ILSAMP Partner Institution A, ILSAMP Partner Institution B, and so on.[1] **Figures 1–3** provide an overview of information about the 54 students who responded to CR&E's request for survey research participation and completed the online survey. **Figures 1**, **2** show the study participants by year of schooling and by their academic major, respectively.

## Data Analysis

All qualitative data were coded thematically using Atlas. ti, with the goal of illuminating and discovering emerging themes. With one exception, quantitative data were reviewed using descriptive statistics. This exception is discussed below. In addition, the three-member research team represented multiple races, disciplines, and generations, which enabled them to bring unique lenses to this study. All findings were reviewed and discussed by the entire research team, and they were revised as needed.

As Patton points out, the flexibility provided through qualitative methods does not imply that findings from qualitative data are not accurate. This study used a number of analytic methods identified by Patton to ensure that the study met

[1]Representation by underrepresented minority groups in STEM by each partner in the research study is as follows: Partner A, 10 surveys, 8 interviews. Partner B, 7 surveys, 4 interviews. Partner C, 5 surveys, 4 interviews. Partner D, 4 surveys, 0 interviews. Partner E, 3 surveys, 2 interviews. Partner F, 5 surveys, 1 interview. Partner G, 4 surveys, 0 interviews. Partner H, 1 survey, 1 interview. Partner I, 3 surveys, 1 interview. Partner J, 1 survey, 0interviews. Partner K, 1 survey, 0 interviews. Quantitative data broken down by partners is reported only for colleges that had 5 or more survey responses.

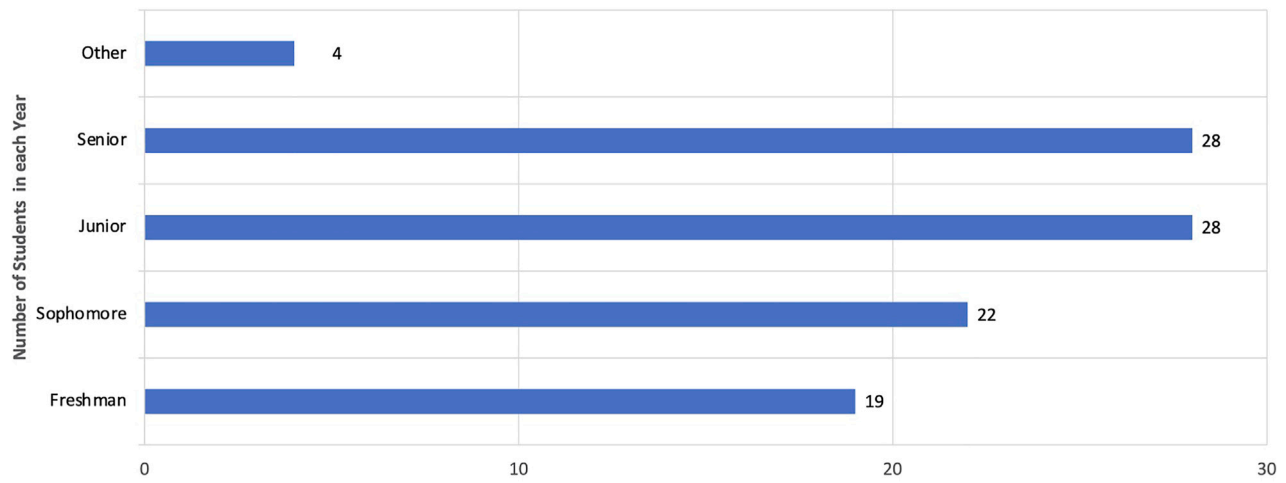


**FIGURE 2 |** Academic year.

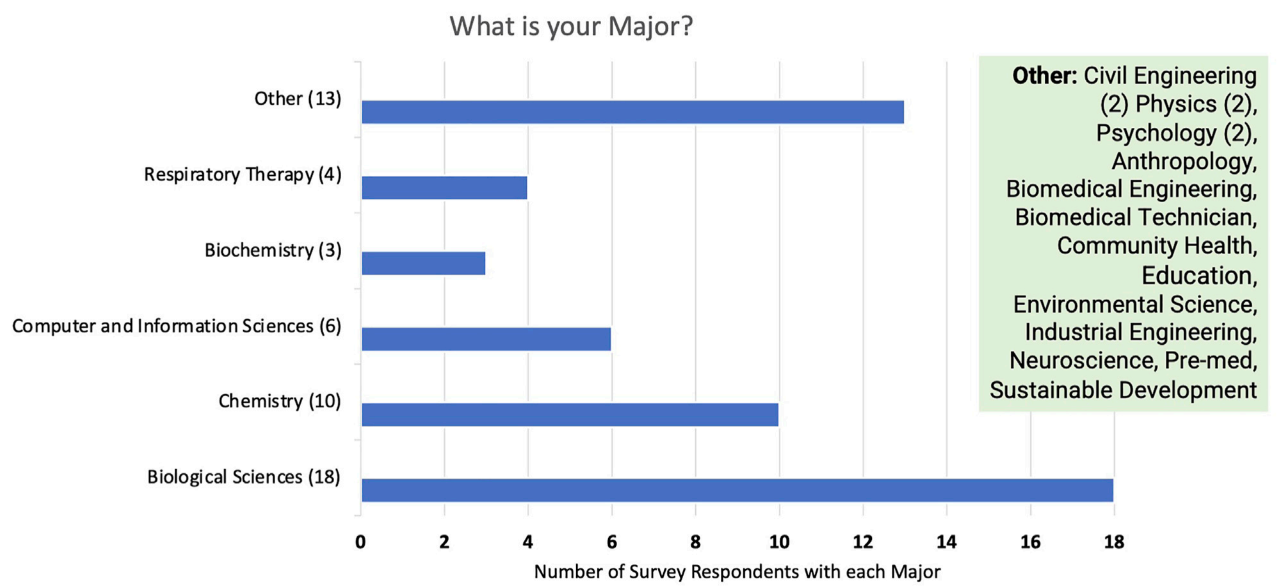


**FIGURE 3 |** Academic major of students in the study.

expectations for utility and credibility. These methods consist of inductive and deductive analysis to identify themes and patterns that applied to the entire sample of participants or to subsets of participants.

In this study, there were five major steps of qualitative data analysis:

Step 1 (Inductive)—Team members reviewed transcripts for individual interviews and identified salient issues for each individual.

Step 2 (Inductive)—Team members identified cross-cutting themes for two groups of schools. The three schools with the largest number of participants were in one group. The remaining schools were in another group.

Step 3 (Inductive): Team members compared cross-cutting themes across the two groups of schools and agreed on major themes to use for the next phase of analysis.

Step 4 (Deductive): All interviews are coded to capture data related to the major themes that were identified.

Step 5 (Deductive): Coded data is reviewed to refine themes and identify findings based on qualitative data.

After the identification of patterns in the qualitative data, findings were extracted by using strategies that Patton refers to as

**TABLE 2** | Overview of student self-ratings.

| Category name | Numerical rating | Quartile | Research Team's interpretation based on open-ended comments |
|---|---|---|---|
| **In Crisis** | 0–25 | Bottom Quartile | These students described themselves and their families as facing serious new problems due to recent events. |
| **OK- 2nd quartile** | 26–50 | 2nd Quartile | In general, students in both these quartiles described less severe or moderate additional challenges due to recent events. |
| **OK- 3nd quartile** | 51–75 | 3rd Quartile | In general, students in both these quartiles described less severe or moderate additional challenges due to recent events. |
| **Fine or OK** | 76–100 | Top Quartile | Students in this quartile described themselves as having moderate or minimal additional challenges due to recent events. |

"determining substantive significance." In inferential statistics, quantitative researchers run tests to determine whether relationships between variables were strong enough to have "statistical significance." One of the important probes identified by Patton that was used in this study is "How solid, coherent, and consistent is the evidence in support of the findings." Triangulation, or the comparison of patterns across different data sources and between different subgroups, is one key method identified by Patton and used in this study.

The survey question that enabled students to use a slider to show their well-being required a different method of analysis than the other items, which were Likert-scale survey questions. For heuristic purposes, student ratings on the sliding scale were divided into quartiles defined by the rating scale (not by number of responses within each quartile). Qualitative review of URM students' open-ended responses was conducted within each quartile (numerical band) and across bands. Based on students' open-ended comments, bands were labeled "In crisis," "OK—2$^{nd}$ quartile," "OK-3$^{rd}$ quartile," and "Fine or OK." A subsequent review of non-URM students' open-ended responses showed that comments by the two subsets (URM and non-URM students) were thematically similar when divided by band. Although these labels are rough, the use of quartiles provides a structure to indicate the range of distress and adaptation in students' self-reports. **Table 2** provides an overview of these ratings.

It is also worthwhile to note that the members of the research team had different frameworks for using the terms "In crisis" and "OK," two of the labels provided on the "wellness" question on the survey instrument. Using the perspective of culturally responsive research and evaluation, the multiracial team discussed these terms and remained focused on what they mean for people who experience the never-ending impacts of American racism. This was an important part of the analytic process and informed the final findings of the project.

# RESULTS

## Black, Latino, and Multiracial ILSAMP Students

In this section, we begin with findings about the experience of interviewees and survey respondents who are members of groups that are underrepresented in STEM fields.

After these findings, there is a short discussion about experiences of STEM students who participated in the study, but who don't fit the category of URM as defined by the National Science Foundation.

Findings about URM students address the following research questions:

1. What is the experience of ILSAMP students and their families during the COVID-19 pandemic and the increased visibility of systemic racism?
2. What is the impact of these two current confounding events on the academic progression of ILSAMP students?
3. What support are students receiving from their institutions and the ILSAMP program?
4. What other supports do ILSAMP students need?

**Figures 4–9** draw on survey responses from the 44 participants were Black, Latino, and multiracial URM students completed the survey. Results in this section also draw on interview data with the 21 interview participants in these groups. Quotations have been selected to represent African American, Latino, and multiracial students from all of the colleges represented in the research study. To ensure confidentiality as promised in attaining student consent, quotes are not identified by letters or pseudonyms. The reason for this is that aggregating the details of "anonymous" students makes identification possible in certain situations.

**Research Question 1:** What is the experience of ILSAMP students and their families during the COVID-19 pandemic and the increased visibility of systemic racism?

**Finding:** Most ILSAMP COVID-19 Study participants rate themselves as "OK" on a sliding scale that ranges from "having problems" through "OK" to "fine."

**Finding:** Even though ILSAMP COVID-19 Study participants are not in crisis due to the COVID-19 pandemic, they are grappling with the persistent crisis of systemic racism.

## Sense of Well-Being

The first question on the survey asked participants to rate their overall well-being and that of their families using a slider. The scale on the slider went from 0 on the left to 100 on the right. The scale was labeled in the following way: Zero on the scale was identified as "having problems", the midpoint (50) was identified as "OK", and 100 was

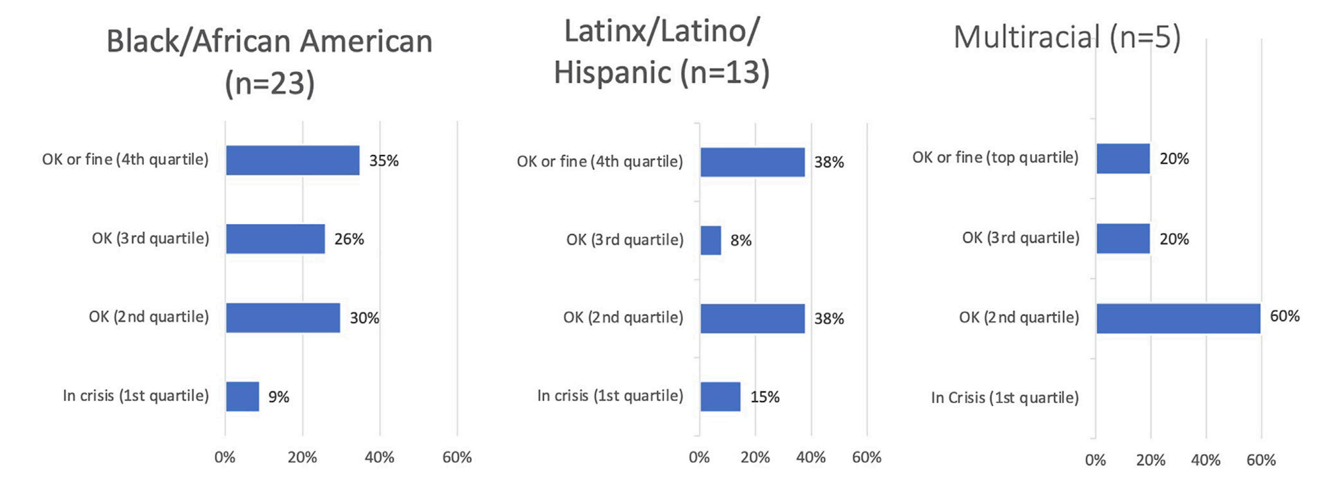


**FIGURE 4 |** How are students feeling? (By race/ethnicity).

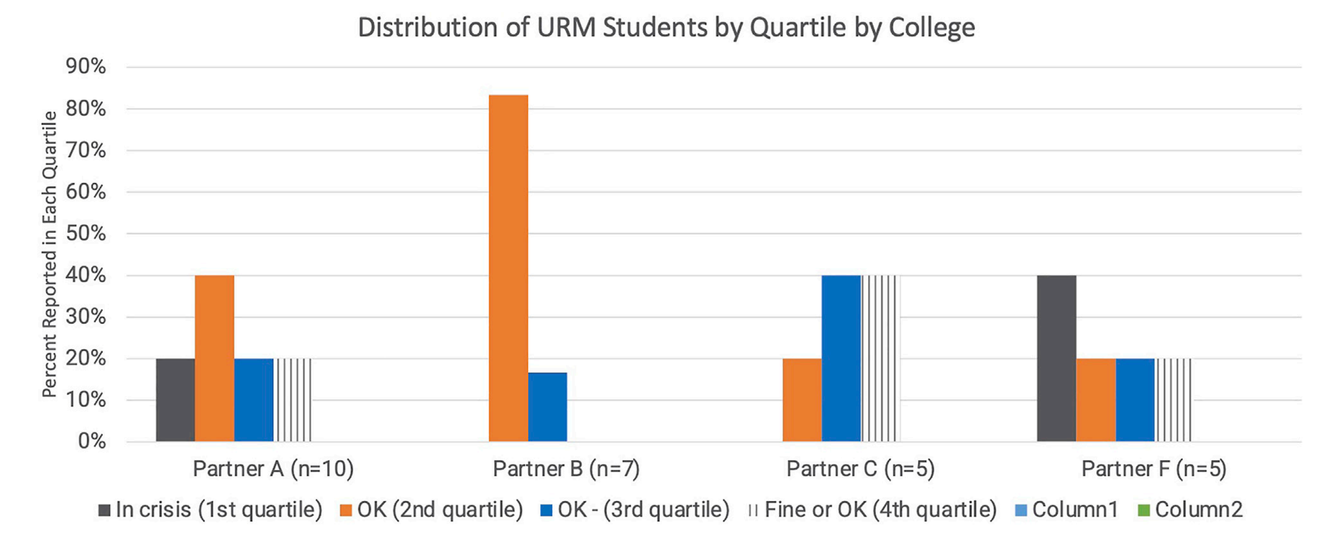


**FIGURE 5 |** How are Students Feeling? (By Schools–with 5 or More Survey Responses).

identified as "fine". The research team's interpretation of the frequency distribution of ratings and central tendency measures leads us to state that ILSAMP COVID-19 Study participants rated themselves as "OK." The average self-rating for all URM students was 58. The median rating was 52. The mode was 50. The text below provides additional information about rating categories and participant responses. Examples of open-ended survey comments from each wellness category of students provide a small window into the many different experiences of ILSAMP students and their families during the pandemic.[2]

[2]The total number of URM students who provided self-ratings was 41. Three additional students shared open-ended comments, but did not rate themselves.

In crisis–Quartile 1 ($n$ = 4): "Father was laid off from his job. Mother owns a pharmacy on the south side of Chicago. It was looted during riots."

> "We are having problems because we stopped working due to COVID-19. It is hard to keep up with food, house payments, and bills."

OK–Quartile 2 ($n$ = 15): "My mom got divorced. We had to find a new apartment, and she had to find a job. She used to be a housewife, so it became somewhat difficult to find a job for her, especially since she is near her mid 50s. Also, right when the pandemic hit, I was placed in mandatory furlough, so I am currently not bringing income to the house."

OK–Quartile 3 ($n$ = 8): "I think we're doing good considering the issues all over place, people, and police

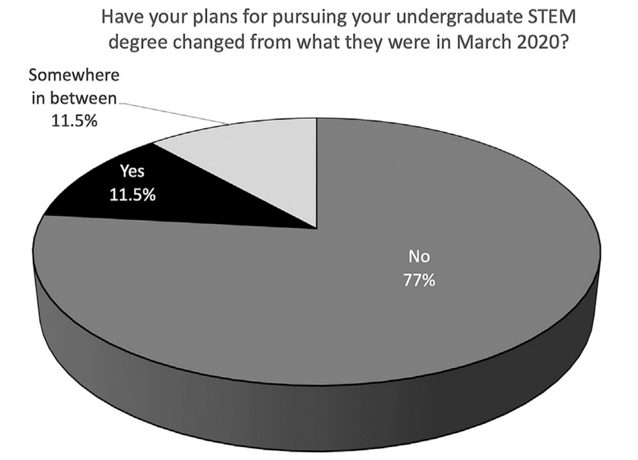


**FIGURE 6 |** Changes in STEM academic plans: Have your plans for pursuing your undergraduate STEM degree changed from what they were in March 2020?

brutality and the COVID-19 pandemic. I do think it could be better."

Fine or OK—Quartile4 ($n = 14$): "My parents still have a job to go to every morning, so things are fine as far as finances are concerned, we just go about our daily routines differently."

**Figures 4**, **5** show the breakdown for COVID-19 Study participant surveys by "wellness" category, racial/ethnic identity, and colleges that had more than five survey responses. These figures show differences across racial/ethnic groups and across schools in student perceptions of the wellness of their family and themselves. However, the sample size was small and the analysis was not designed to explore inter-group differences in sense of wellness.

**Figure 4** shows that of the students who responded to this survey, Latinos had the largest percentage of students who rated themselves/their families at 50 and below on the rating scale, as well as the largest percentage of students who rated themselves toward the top of the scale. For Latino students, the mean rating was 52, the median was 50, and the mode was bimodal with two modes: 80 and 90. For African American students, the mean rating was 63, the median was 52 and the mode was 50.

In open-ended comments provided to explain the ratings, students from all racial and ethnic groups reported that their family members were sick or out of work due to COVID-19, but this was a more frequent situation for Latino students responding to the survey. In addition, as shown in **Figure 5**, students from some colleges were more likely to rate themselves in the bottom two bands than students from other colleges. **Figure 5** displays student self-ratings aggregated by ILSAMP partner institutions where five or more URM students completed the survey. Although the data set was very small, Institution F is especially noticeable for having a high proportion of students who described themselves as having problems. All of these students also identify as Latino/Latinx/Hispanic.

## Crisis of Systemic Racism

Students interviewed were asked about how the current wave of protests against police brutality affected their experiences as STEM students at their respective universities. In their responses, students reflected on how the protests resonated with their individual experiences, how their academic plans were impacted, and what supports were helpful in navigating their own emotions during this time. When speaking about how the protests resonated with their individual experiences, many Black students were reflective and well-invested in the issue behind the demonstrations:

> "I dealt with a lot of depression during that time. I related my life experience with what was being protested. I wanted to look away but, as a Black person, I knew I could not."
>
> "As a Black man in America, [police brutality] has had very real reverberations in my life. I live in the West Loop, and commute to O'Hare. There's an increase in police patrolling. Increase in police mobility."

Some of the Black students interviewed mentioned their concern about having to educate colleagues on racial injustice, particularly because their work environments were largely occupied by white colleagues:

> "I usually work with White peers and colleagues. Being able to stay home when the protests were happening allowed me to be protected from co-workers asking about my opinions and for advice. Working-from-home protected me from any danger."
>
> "Not a lot of minorities work in my field. It was not easy to focus so much on the work. I don't feel responsible to teach them [white colleagues]. I come to work for work, not to teach social justice."

Other students (Black, Latinx, and multiracial) felt personally impacted by the looting occurring in their local communities:

> "It was very scary. I was lucky enough to not have to go out to work. Many stores close to me were affected. It could be said that it was unrelated to the real reasons for the protests. There was a lot of confusion."
>
> "I was frustrated because many of the grocery stores near my home were closed due to looting, so I had to go far to get groceries. My internship was also in the city and I had to get there four days a week. It was a mental strain thinking of how to travel there safely."
>
> "There was so much tension between gangs and protestors in my community. At one point, police weren't really doing anything [to intervene]. The gangs decided to run it, and would not let any Black people come into Pilsen or Little Village. It was a stressful time for my family living in those areas."

"Within the mile radius [of] where I lived, stores and transportation were shut down and I had to leave the community to get the things I needed. I was always wondering if we would be looted or if I would be stopped by police. I was very anxious, so I didn't even want to go outside to take a walk and clear my head."

When speaking about how their academic plans were affected, some students from all URM subgroups commented on how the protests sparked motivation in their academic pursuits and overall involvement in the movement to end police brutality:

"But the protests made me feel very angry. I did not like the social injustice at all but I feel it motivated me to push harder at what I'm pursuing."

"It has not motivated my plans, but I am getting more involved in organizations and issues pertaining to police brutality."

"It (the protests) was all over my Twitter feed and I felt like I really wanted to go out there and sacrifice myself, but I had to ask myself if that is something I should do as the best and most productive thing for me, given what I want to achieve for my people. I don't want to sacrifice myself to COVID. . . . I have always been aware of my Blackness and our trials, and felt that personal and business need to be separated. I am about the goals I set for helping my people. (The protests) make me want to learn more to do more."

**Research Question 2:** What is the impact of the two confounding events (the COVID pandemic and the increased visibility of systemic racism) on the academic progression of ILSAMP students?

**Finding:** Most ILSAMP COVID-19 Study participants are motivated to continue with STEM and plan to continue their studies, even if their specific plans have changed somewhat.

**Finding:** Survey data shows that ILSAMP COVID-19 Study participants were most impacted by the pandemic in their abilities to manage internships, in their increased financial needs, and in the increased amount of time it will take them to graduate.

## Motivation to Continue With STEM

Survey data, as shown in **Figure 6**, indicates that most study participants are committed to continuing their STEM studies. In their interviews, students conveyed their hope and their enthusiasm. In many cases, fear about the pandemic coexists with commitment to continue in STEM. Students expressed many concerns and problems:

"[The spring] was really hard. All lectures moved to zoom, [and I was on] without a camera. It's easy to get sidetracked and distracted. . . . I did not get to finish. I was looking forward to research and did not get to do it."

Since the pandemic hit, many students also had a harder time thinking about the future and their plans. Other students remain upbeat, even while they are worried. As one student commented, the pandemic both inspires and scares her:

"I'm concerned mainly about the social distancing. How will we get back into the lab? What will we do? How do we maintain six feet distance? I want to continue in research and better my understanding of my major. The pandemic will make me stronger. It inspires me to work in research. As long as we can implement the safety standards that the CDC [Centers for Disease Control and Prevention] wants me to abide by."

Several told us that even though their work was slowed down, they are even more inspired.

"My plans to graduate haven't changed. I will go to graduate school in chemistry. The pandemic has slowed down my research. I couldn't get into the lab. I wasn't impacted by the protests. But I was very angry, and I did not like the social injustice at all. But I feel it motivated me to push harder at what I am pursuing."

One recent transfer student from a two-year school to a four-year school said that her biggest regret was missing an opportunity for a fully paid scholarship to study abroad during the summer of 2020. She also slowed down her research so she wouldn't increase the risk of COVID-19 for her large family. This student has been very engaged with her college community and plans to graduate with a four-year degree in environmental science in 2022–23, after an earlier period of indecision during the summer. Looking forward past the bachelor's degree, she remains motivated to get the broader experience outside of the United States that she missed out on:

"I definitely want to continue my education, but I haven't looked into it specifically. I would want to study in a different country and be less biased in my own learning, especially given my environmental sciences major. U.S. policies are a little bit behind. I want to learn from other places."

## Impacts on Internships, Finances, and Time to Graduation

**Figures 7**, **8** provide numerical assessments of what changed and what didn't change as a result of the COVID-19 pandemic. Finances were one area commonly mentioned by students who were interviewed:

"They are still forcing us to participate in a meal plan [that I don't like] because of safety reasons. We are forced into something for the sake of generating revenue."

"I will be going [out of town] for my master's. It turns out that classes will be online this fall. I wish I had

> known that before I signed a lease. I am working to find additional funding because not all things are covered by my scholarship."
>
> "The problem with all my scholarships is that I need to be full time and it was very frustrating to find virtual classes to do that."
>
> "I got terminated from my job because of the pandemic. I'm trying hopefully to get it back."

Interviewees also identified many disruptions in internships and other plans:

> "I lost out on money from not doing the internship and I'm figuring out if it'll take more time to gain experiences. I wanted to boost my application for med school."
>
> "It's very difficult to coordinate classes. I'm not sure it'll work out for the fall. I might need to take another semester before applying to the MD/PHD program for fall 2020."
>
> "I will not return to school full time. I live in West Virginia and there is no community college here whose credits [my school] accepts."
>
> "The biggest change was that I was set to study abroad this semester in China, then in Korea."
>
> "This will be my last year as a senior. I am in the process of applying to grad school and I feel that COVID has slowed my application because it has interrupted my research."

**Research Questions 3 and 4:** What support are students receiving from their institutions and the ILSAMP program? What other supports do ILSAMP students need?

**Finding:** Most ILSAMP COVID-19 Study participants have received valuable support from their colleges or from their ILSAMP coordinators. However, the students have many more needs.

**Finding:** ILSAMP COVID-19 Study participants reported a high degree of frustration and disappointment with online learning. Students need support for negotiating these challenges, and faculty must be fluent with best practices for this pedagogy and need to have adequate technical support**.**

**Finding:** Several ILSAMP institutions provide examples of communication and community-building approaches that need to be expanded in the current environment.

## Supports and Needs

In surveys and interviews, ILSAMP participants from all colleges reported both positives and negatives about the support they had received from their schools and their campus LSAMP initiatives.

Financial support was the most frequently mentioned factor, both as a positive and as a negative. **Figure 9** provides an overview of survey responses about support. On the positive side, students frequently mentioned that they appreciated generous CARES grants that they received through their institutions. Many students also commented that their colleges and professors were doing the best they could in a difficult situation. In rarer cases, some students said that their colleges care about them and shared information effectively. When students expressed this level of trust in an educational institution, they either identified a specific individual with whom they felt connected or they mentioned the financial assistance. For example, one student who rated themselves at the lowest possible level of wellness (0) commented in an open-ended survey question that:

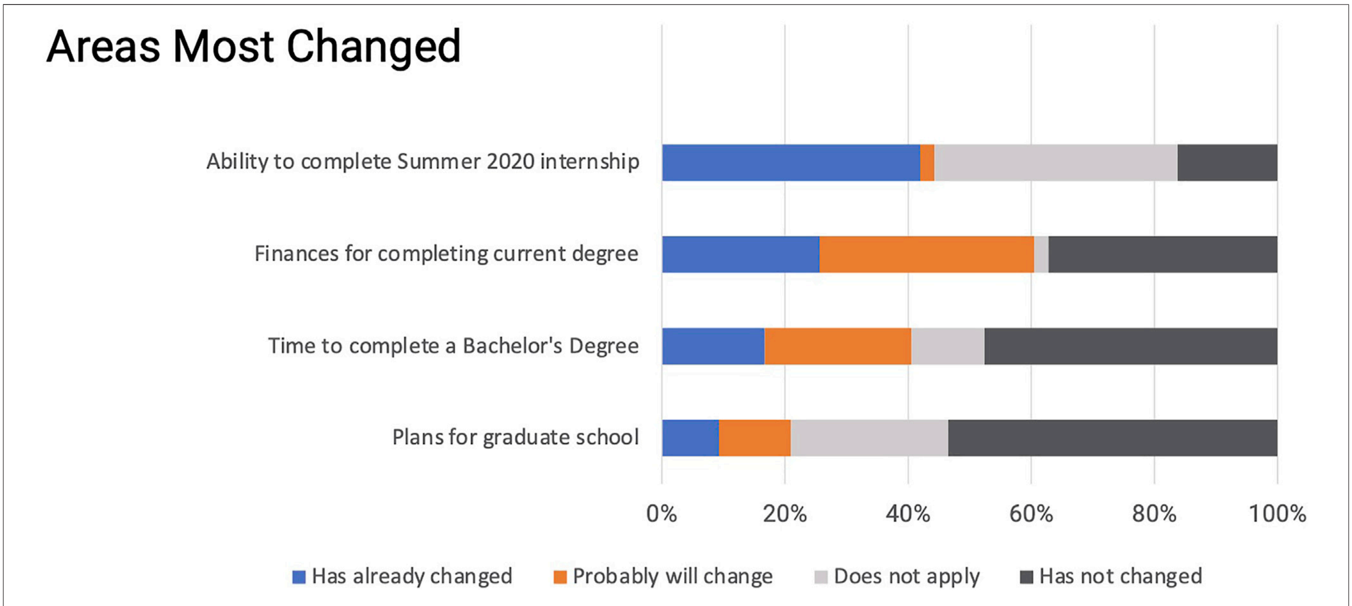


**FIGURE 7 |** What has changed as a result of covid 19? (Areas most changed).

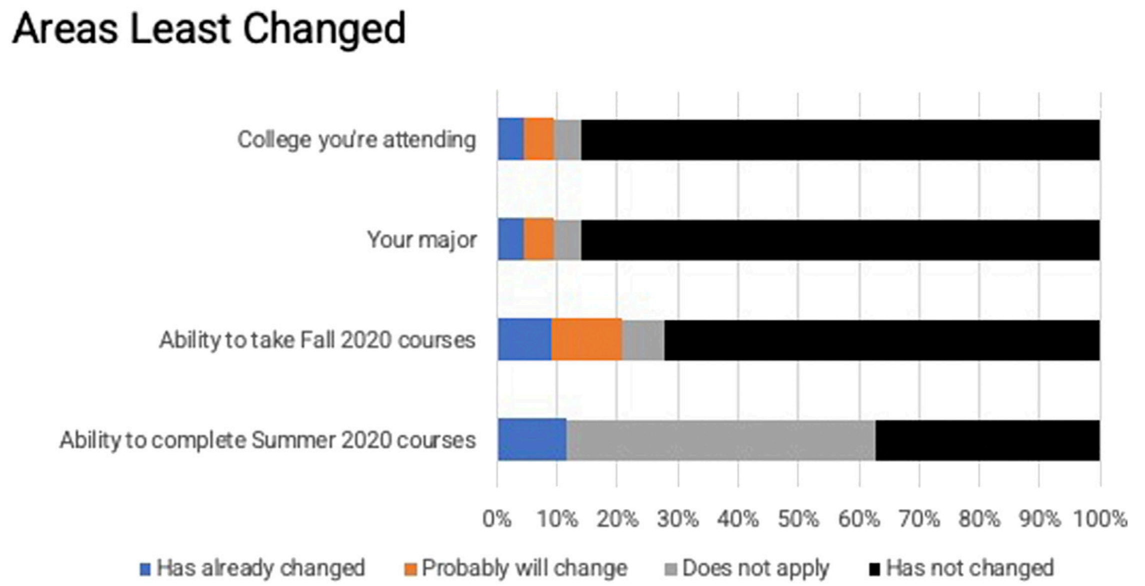


**FIGURE 8 |** What has changed as a result of covid 19? (Areas least changed).

> "We had the opportunity to apply for help because we had extra expenses at home and a lot of us got a check. This kind of helps us feel like they care about the situation."

On the negative side, many students also expressed anger at being charged full price for online education when they were not getting the equivalent value in course content and interaction with faculty and peers. Other material requests include additional grants, increased pay rates for student workers, and information about how to access basic needs such as food, housing, and personal protective equipment to avoid infection by the virus. Students also frequently requested clear, honest information about their institutions' plans for classes and for maintaining safe, healthy campuses.

Based on surveys and interviews, students at all colleges reported both positives and negatives about support from their colleges. However, several trends emerged:

- Several ILSAMP Partner Institution A interviewees mentioned the value of connections with specific mentors, with research teams, or with faculty connected with the learning assistance program.

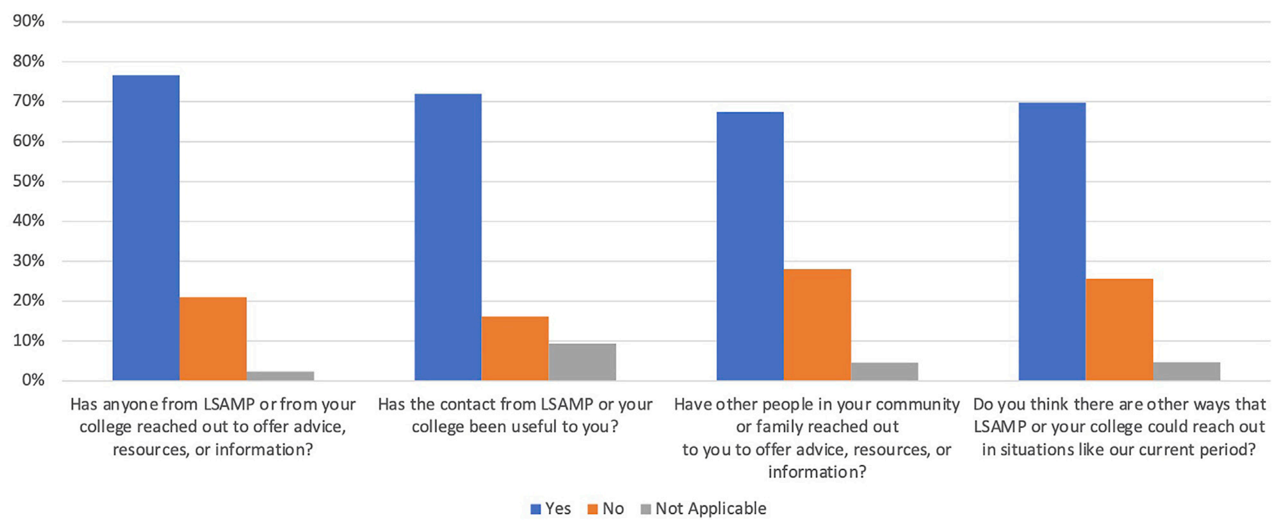


**FIGURE 9 |** Satisfaction with supports received.

- Several ILSAMP Partner Institution C students commented in interviews on the value of a Zoom meeting about anti-Black violence and racial profiling organized by a faculty member who is also the ILSAMP coordinator.
- All survey respondents from ILSAMP Institution E reported that the assistance from their college or ILSAMP was valuable. In interviews, these students clarified that a representative had reached out to Black and Latino students to make sure that they knew the grant application process.

Responses from students from other colleges showed no clear themes or did not have enough responses to identify either positive or negative themes. In some other colleges, individual students did identify specific people they were connected to. Sometimes these mentors were identified as being connected with ILSAMP, and sometimes they were identified as not being connected with ILSAMP. Students from several colleges mentioned that they were disappointed not to have heard from an ILSAMP representative or that they had not heard at all from individual STEM faculty members.

## Frustration and Disappointment With Online Learning

Students interviewed were also asked about their individual experiences with virtual learning during their Spring 2020 semester. Overall, students faced challenges with the following:

- Stress management
- Access to resources
- Academic and technical support
- Other logistical problems.

Some students welcomed virtual learning as an opportunity for increased flexibility in their schedules:

> "I took advantage that classes were online and continued to work [at the hospital] as I needed to. I appreciated the flexibility of the online, nonsynchronous method."

Some students had mixed feelings about online instruction:

> "Online classes are manageable but very hard to resist distraction. The workload and instruction have been fine."

Many students expressed frustration with the transition to online learning in the Spring. Students said it was difficult to remain focused on instruction while facing the stresses of the pandemic. For example:

> "The online experience was horrible. It's depressing and not at all motivating. It is very hard on the eyes and the connections with technology was really bad."

> "The cultural environment was already very poor before the pandemic, as the students didn't really talk to each other. When the professor broke us out into working groups, no one talked in the working groups. There was no one to facilitate the groups, or deal with persons who were just really depressed."

Student after student reported that they did not have adequate access to technology, instruction, or other supports needed to successfully complete course expectations. For example:

> "I had to scrape money together for a new laptop. Some classes like Calculus 3, thermodynamics and chemistry lab were designed to be in person."
>
> "It was hard for me to study at home and find space for listening to and focusing on lectures. They could have refunded more money to us given that we had to rely on our own WiFi quality. I missed many things due to WiFi going down, I couldn't ask the professors to repeat it."
>
> "A lot of the material learned in class is usually clarified more in class. The professor can't gauge confused looks because all lectures are previously recorded and posted online."
>
> "I missed having study groups. Not having that made it more difficult to stay on top of deadlines. It was hard to keep track of everything going on."
>
> "The online courses are different, especially for STEM majors. . . . Anything could be on the test, even if they had never even gone over it in class, just to make it more difficult."

## Examples of Communication and Community-Building in the Online Environment

Several ILSAMP institutions also provide valuable examples of communication and community-building approaches that need to be expanded in the current environment. Areas of challenge and problem-solving in the arena of student-staff-faculty interaction were:

- Faculty flexibility
- Mentor preparation for the virtual world
- Real connections between mentor and intern
- Community-building.

**Table 3** provides examples of challenges in communincation and relationship building and how they are being met. Based on our research, none of the ILSAMP campuses provides a complete model, and this table draws on quotes from students from a variety of different schools. We share these examples to give glimpses of the types of activities that are likely to be especially important for translating LSAMP's framework into a virtual, post-pandemic, race-positive world, with a framework that

**TABLE 3 |** Challenges and solutions in communication and relationships.

| Challenges | Solutions |
|---|---|
| **Faculty becoming inflexible** | **Faculty becoming flexible** |
| My teachers did not lift any of the grading requirements. It was insanely unfair. They were offloading all of the responsibility onto the students. | I was taking C+. It required a lot of self-teaching. The teacher did his best. He knew that all of us were not very familiar with taking online courses. He was very understanding if someone couldn't get online right away. He recorded it so they could watch it later. He was very good if we sent him emails or something. |
| **Mentor without preparation for virtual world** | **Mentor with preparation for virtual world** |
| My internship was with Oakridge National Laboratory in Tennessee for 10 weeks. I was disappointed not to be able to attend live. We did it virtually. I feel that my mentor did not respond to me as he should have—not as accessible, he clearly was not comfortable in using the technology. I had to constantly reach out to him. I sent him my paper 3 weeks before it was due. He never got back to me so I submitted it so that it would be on time. | I did an internship at Argonne, which was from May 26-July 2020. I think it went as well as possible. My project involved coding so I would have been online anyway. Everyone tried to mentor us as well as possible online. The research project that I was doing at went well, as well. It was mostly written research, I did a poster and then engaged in presentations online. It was a different experience, but it went well. |
| **Sharing information with no interpersonal connection** | **Sharing information as part of an ongoing mentoring relationship** |
| Without the guidance of an advisor, it is significantly more difficult to sign up for the classes I need. Advisors have reached out remotely. It is not the same. It takes a lot longer. There have been a lot of technical difficulties. A lot of busy-ness. I am worried about miscommunication. The advisors don't fully understand the question because I haven't been able to explain it in person. | I have been getting help from the state in cash assistance and food stamps. I was working at the hospital. Now I have a [different job] and am also doing research with my advisor. She has been very helpful. She checks up on me to see if I am alright and sends me emails through the day with information. |
| **Desire for community** | **Building a community** |
| My school did a pretty good job in giving updates. There were a couple of updates. There were a couple of events that showed there was still support to students. Anything else that could break the social distance would be helpful. I would love more of a sense of community. I would benefit from having conversations about what is going on now. Just starting the conversation, sharing experiences and resources. | I also belong to the group that does tutoring. A lot of people know me there, and they all reach out. My counselors also know me because I am a tutor. We try to know what is going on with everyone. I think [this communication] helps you to cope with being isolated. It's especially good that one of the counselors started organizing lunches to talk about what's going on with the students and basically to improve everything. |

could be adopted by other alliances as well as organizations and institutions seeking to address STEM equity issues.

## Experiences of Non-URM Students

We also looked into the experiences of students who responded to our request for research participants, but who were not considered "underrepresented minorities" in STEM by the National Science Foundation and are thus outside of ILSAMP COVID-19 Study participants highlighted above. Discussing the experiences of participants in LSAMP activities who are not URM students can shine a light on the processes and support systems needed across all campuses. The interviewees from this group included one Chinese American woman, one white woman, and one Filipino woman. Eight white students and two Asian students responded to the survey. Students in these categories were not eligible to receive LSAMP stipends, but were invited to participate in ILSAMP events and were connected to other external funding sources.

Survey data from white and Asian students shows that as a group they report higher wellness scores than URM students. For seven white and two Asian students who supplied ratings, the mean was 64 and the median was 72. Among these nine students, each rating was different, so there was no mode. Looked at by quartiles, we report the following information. The comments for non-URM students within each quartile are similar to the comments for URM students in the same quartile, although the distribution between quartiles is different.

In crisis–Quartile 1 ($n = 1$): "We are struggling to pay our bills and put food on the table due to covid-related job loss and fear of getting sick."

OK–Quartile 2 ($n = 2$): "My father owns his own business and due to COVID-19, business has slowed significantly. Currently, my family is living on profits from last year and hoping that business booms again soon."

OK–Quartile 3 (n = 3): "I'm doing ok, the family is also. Our jobs have been affected and it is stressful but I am coping."

Fine or OK–Quartile 4 ($n = 3$): "My family is always supporting and caring for each other. . . .when we face problems we will put (conflicts) aside and be united."

The perspective of the Chinese American interviewee highlights the importance of personalized outreach and communication with any students who may be at risk. This student experienced anti-Chinese harassment that resulted from racist rhetoric used by U.S. politicians in addressing the root origin of COVID-19. Because this particular student is excelling academically, her mental, psychological, and spiritual health may be flying under the radar of advisors or mentors. Through sharing her experience with researchers, this student highlighted her heightened exposure to risk and her need for support from a community like ILSAMP. Her experience should be a wake-up call to ILSAMP, adding to the reasons that processes and support systems need to be put in place across campuses that can benefit all participants, especially at a time when various groups and individuals are targeted by xenophobic, white nationalist sentiments.

She gave more details:

> "My family is doing well overall. We are safe and have had the ability to shelter in place. I was able to finish in the spring and maintain my 4.0 and I have been doing my student research at my school. This (pandemic) has hit me more mentally and psychologically than anything else. I am very empathic and when we shut down in the spring, people were very fearful of the disease."

As a Chinese American, she is part of a community that has been targeted since the president of the United States repeatedly blamed the COVID-19 pandemic on China.

> "I used to work in Chinatown. I stay in touch and I know that restaurants there are being harassed (In my own neighborhood,) people walk past my porch and cross the street. I have a history of anxiety, and this heightened it."

The college and the ILSAMP program have done little or nothing to address these issues or even acknowledge them.

(My school) has a coronavirus task force that gives us weekly updates and advice on coping, like meditation, but it's not very proactive. I am not aware that ILSAMP has reached out. Just the recent survey and then this interview. It's hard to say whether anything is happening because everything is so remote. They could have provided social Zoom sessions so that we still felt like part of a university family. There could have been more cohesiveness, letting us know that the world was "still here."

A white student from a different college provided an additional lens in this study, sharing her experiences during this time as someone living and learning with physical disabilities. She highlighted the importance of personalized outreach and communication for all students during the current crisis and describes both the challenges and support she received from faculty and staff at her two-year college.

> "My family is doing pretty OK. We generally keep to ourselves. My mom had a stroke last year. My mom, my son, my brother, and I live with my grandmother."
>
> "It's stressful to start the semester. My son has ADD and he's in special education. I'm also dealing with the complications of giving my sister a kidney. For me as a student, it's kind of difficult doing the online classes. I'm grateful to still be able to complete classes, but I appreciate the in-person way more. With my learning disabilities, it's hard to concentrate. . . . I was taking intro to organic in the spring, finishing the class online. It can click when I'm there in person, but not online. I ended up passing with a C. There was no way to get an A."

This student counts on her campus office that supports people with disabilities and relies on the support of her advisor, who is also the ILSAMP coordinator for this school.

> "What's been helpful is my advisor and the people in the office. A lot of students don't take advantage of the many resources going on at school. I've been working with an advisor to maintain my funding after 6 years at this school. I used up all financial aid, and I'm trying to work that out."
>
> "The college and LSAMP did a really good job, asking me 'How is your day going?' They generally really care. I'd like to go to graduate school, but my learning disabilities make me apprehensive."

The ability to develop this relationship prior to the pandemic was essential in facilitating the student's ability to access accommodations and support during the current crisis. The situation highlights the need to focus even more attention at the current time on providing space for relationship-building.

Other examples include several ILSAMP students who identify as non-binary and ask that ILSAMP see and recognize them for who they are. One of these survey respondents is a white student from a family that is experiencing a financial crisis, like several of the African American and Latino students' families detailed above. After completing the first year of college, this student's timeline for completing college had already changed as a result of the pandemic:

> "We are struggling to pay our bills and put food on the table due to COVID-related job loss and fear of getting sick. I wish my school would give more financial aid to its students."

The feelings of isolation and marginalization described by these non-URM students who are part of the LSAMP sphere intersect in many ways with the feelings of isolation and disconnection described by the URM STEM students in this study. The lenses that the non-URM students offer on issues such as anti-Asian racism, disability, poverty, and gender difference point to a deep need for LSAMP staff and faculty be tuned into the multi-faceted realities of all their students. Openness to the complexity of student identities, as well as skills in reaching out to different groups of students in times of crisis, is one way to strengthen the entire LSAMP community, including its core population of URM students.

# DISCUSSION

## Implications of This Study

We report here on findings based on work that was primarily empirical and practical, with the goals of identifying what was happening and what could be done to assist URM STEM students during the crisis that began in March 2020 in the United States and continues as this manuscript is being prepared. The project was not designed as an examination of theoretical issues of URM student retention in STEM. However, during this period of crisis, pre-existing patterns of inequality, as well as challenges to them, became more visible across the country. Similarly, this short-term, crisis-focused study provided a valuable lens for looking at the needs and strengths of URM STEM undergraduates. Thus the voices of young Black and Latino students during this crisis period do have relevance to several theoretical constructs that underpin interventions for student success and retention.

ILSAMP students generously shared many suggestions for the needed supports in the current environment. To a large extent, student recommendations overlap with key elements of the LSAMP model—academic support, community, and professional opportunity (**Table 1**). These needs are exacerbated by the current crisis, and student voices underline the relevance of the key elements of the LSAMP model. In spite of the practical relevance of LSAMP as program framework, student interviews also highlight gaps in Tinto's conceptual framework, which gave rise to many of the elements that have been incorporated into LSAMP.

In particular, this study shows the gaps in a conceptual framework that focuses on integration and belonging, but fails to theorize concepts related to student agency, racial identity, and racism. The motivation and determination of URM students to pursue their STEM careers in the face of adversity of the Covid 10 pandemic a remarkable theme in this study. Experiences with race and racism were also highly salient to study participants. This sample was small, and it is quite likely that students who were more motivated were the ones who responded to the researchers' request for study participants. Nevertheless, these participants demonstrate that an adverse context including attacks on science and a health crisis can motivate, rather than deter, URM STEM students.

On a theoretical level, a conceptual model that employs concepts of "integration" or "belonging" without recognizing the complexity of student identities will miss the role that URM students' racial identities, family identities, and community identities play in contributing to a commitment to pursue a STEM degree career. Similarly, a conceptual model that ignores what Hurtado refers to as "exclusionary cultures"of higher education will miss the ways that faculty and staff are often oblivious to the lived realities of URM students.

On a practical level, student experiences during this period of crisis show that is essential for college faculty and staff to a) be attuned to racial trauma; b) be comfortable talking with students about race and racism; and c) ensure that they have developed trust and connection with all students.[3]

## Student Recommendations and Requests

These can be divided into two broad categories: financial needs and safety and connection to community. The increased visibility and exacerbation of U.S. racism in the United States also highlights the need to explicitly address racial trauma with LSAMP students (Comas-Díaz et al., 2019).

## Financial Needs

First, faculty, staff, and administrators should be advocating for increased funding to support the education of URM college students at this time. Across the board, the need for financial assistance is a great priority. It is important to note that the students who participated in this study are most likely to be those who are least in need—their participation indicates that they had the time, the place, and the technology to take part in a study like this (Ball et al., 2019).

Students who participated in this research identified needs for: additional grant money; tuition reduction; jobs to replace their lost jobs; and information about access to basic resources (food, shelter, medical assistance). Staff and faculty are in a position to share information with students about available resources and to advocate for additional funds. Many resources provide information about strategies for increasing material support to students during the pandemic and other crises. At the national level, the National Science Foundation can ramp up funding to engage URM students and professionals across the country in the current period. One option is to research and implement best practices for creating a virtual professional development and research network. This could be a targeted source of stipends for participating students who are badly in need of immediate resources. This type of virtual network is a natural extension of the networking that has consistently grown through LSAMP. It has the potential to motivate both students and faculty to reach out in new and needed ways.

## Safety and Connection to Community

Faculty, staff, and administrators should be working to ensure a sense of safety—emotional, social, and physical—for their students. Communities of color and immigrant communities are under attack (Morey, 2018), not only due to a health crisis, but *also* because they are targets of police, racists, and other fear-mongers—egged on by national leaders and their allies. Students of color are at risk. Therefore, those responsible for LSAMP and similar programs need to engage proactively with the threats facing their students on campuses and in their respective communities. The Partner Campus C Zoom meeting about racial targeting is a good example of this. Others include training in active listening and sensitive questioning by white faculty members about whether students feel that they are in danger. Additional resources are available through many racial justice organizations.

We make some recommendations to support STEM students of color that may also be applicable to Alliances across the country or other organizations seeking to provide and promote equity in STEM. These would build on the existing strengths of LSAMP and would position the model as a resilient building block to help students face unknown future crises:

- At every campus, program staff and faculty need to help URM STEM students stay connected to their college and stay committed to achieving their goals. Setting up online study sessions and group talking sessions are low-hanging

[3]This last point would include recognition that the ways that students self-identify are often different from the racial categories used by the National Science Foundation. For example, a student who is classified as African-American/ Black or Latino/Hispanic, might identify more strongly with a national identity of their country of origin than with a U.S. racial category.

fruit in terms of support strategies. Strong and ongoing mentorship by faculty members is essential in helping students to stay motivated, negotiate the constantly shifting information available from universities, and mitigate the consequent anxieties that are likely to continue for the foreseeable future.

- At all LSAMP alliances, there should be communication among coordinators about what has proven successful at each of the campuses in supporting students, helping them address a racist environment, and accessing funding opportunities. Students on some campuses report feeling more connected than students on other campuses. LSAMP coordinators should share what they are doing to help students during this period.
- Students on every campus should feel that LSAMP is a program that cares about students. LSAMP should utilize online spaces for students to interact with each other and with professionals who look like them. LSAMP conferences have been valuable spaces where student participants learn about new opportunities, where achievements of Black and Brown students are celebrated, and where information about STEM pathways is shared.

## Limitations

By its nature, this study was limited in timeframe and scope. It raises many additional questions:

- First, it would be valuable to conduct a longitudinal, qualitative study of students who expect to continue their education in STEM. Do African American, Latino, and multiracial students who are motivated and committed during the summer of 2020 continue their pathways as they expect? What stays the same? What changes? What supports and challenges do they encounter along the way? What adaptations are ILSAMP, departments, and other programs able to make to continue to provide high-quality educational experiences to their students?
- Secondly, it would be useful for a future qualitative study to contact students who were "missing" from the current research project. Targeted outreach to these students might be possible through LSAMP coordinators and peers at their colleges. These students are absent from this study, but they would be an important part of the story of how students of color negotiate their identities as college students and as community members.
- Finally, it would be valuable to collaborate with LSAMP partners and access university databases in order to compare changes in STEM enrollment patterns among African American, Latino, Indigenous, white, and Asian students. This would provide information about a much larger group of students than was feasible in the current design, which was limited to students who were already engaged with ILSAMP or other STEM research opportunities. In addition, collecting data from colleges would be a way to access information about students who are less engaged or who may be facing other critical problems and may not be likely to respond to research requests like this study.

# CONCLUDING COMMENTS

In conclusion, URM STEM undergraduates who participated in this study maintained a commitment to their educational goals while facing the challenges of the COVID-19 pandemic. For many students, racial and community identities contributed to their commitment to achieving success in science and related fields. While LSAMP programs provide important avenues of success for URM students, many students in this study described a sense of disconnection from their professors and institutions during this period of crisis, suggesting the importance of additional attention to deeper relationship-building in LSAMP and similar programs. Furthermore, theoretical work about student agency, racial identity, and science identity would also be important to have fuller understanding of the role of LSAMP and other programs in supporting student success.

In addition, it is important to note that the online format adopted in this study may exclude a group of URM students who may be in dire need and therefore unable to participate in this study because technology is lacking or limited for them (Ball et al., 2019). The students who participated in this study are, by and large, motivated and committed to attaining their STEM degrees in spite of a challenging environment.

This study uncovered hope, optimism, and tenaciousness among ILSAMP students as they face challenging circumstances while pursuing their STEM degrees. Additional research could further examine the depth, breadth, and limitations of LSAMP student progress amid such conditions.

# DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material,** further inquiries can be directed to the corresponding author.

# ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Chicago State University IRB, amendment on Protocol #: 015–06–17. The patients/participants provided their written informed consent to participate in this study.

# AUTHOR CONTRIBUTIONS

CB, SB, LJ, and MD were involved in the design of the study. SB, MD, and MC were involved in quantitative data acquisition, and data analysis. CB, SB, and MC were involved in manuscript preparation.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.681027/full#supplementary-material

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# Synergistic Interaction of LSAMP Alliances to Improve the Graduation and Transfer of Community College Students in New Jersey United States

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The Garden State-LSAMP (GSLSAMP) alliance works collaboratively with the Northern New Jersey-Bridges to the Baccalaureate (NNJB2B) to greatly improve the graduation of community college students from underrepresented minority (URM) groups in STEM and their transfer rate to 4-years STEM programs. This is accomplished through several areas of enrichment. The two alliances sponsor joint activities to encourage a supportive community of 2-years and 4-years students. Community college students conduct research in the labs of mentoring faculty at 4-years programs where they interact with 4-years college students. A cross-campus near-peer mentoring program pairs recently transferred GSLSAMP mentors with mentees from the mentor's community college of origin that eases and facilitates the graduation and transfer of mentees. In addition, the NNJB2B has adopted five proven high impact practices from GSLSAMP for their students. The results are that the graduation rate of the NNJB2B increased an average of 24.0% annually over the first 5 years of the program and the transfer rate improved 151.0% over the 2012 baseline. Four GSLSAMP 4-years institutions were especially active in the program and experienced an average increase of 62.9% over the 2012 baseline transfers from NNJB2B community colleges.

**Keywords: lsamp, community colleges, transfer rates, learning communities, synergistic interactions, underrepresented minorities**

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## INTRODUCTION

Students from economically disadvantaged communities often opt for community college as an entrance to higher education because they are more affordable, have more flexible scheduling and are closer to home. According to the National Center for Public Policy and Higher Education (2011), approximately 44% of low-income, underrepresented minority (URM) students enroll in community colleges as their first postsecondary institution compared to just 15% of high-income students. In comparison to 4-years colleges, community colleges enroll significantly more students from underrepresented demographic groups, including racial/ethnic minorities, low-income, first generation, and nontraditional-age college students (Juszkiewicz, 2020). These groups face significant challenges to persistence in college including lack of familiarity with higher education and its relevance, inadequate preparation for college, limited English language skills, social and cultural foreignness of university and financial concerns (Melguizo & Dowd, 2006; Alexander et al., 2007; Johnson and Cuellar Mejia, 2020). Alexander et al. (2007) found that, for working-class Hispanic students, finances were a major constraint to university, with many students working to pay for their educations as well as to help their parents financially. In 2017, the percentages of undergraduate students enrolled in community colleges were 44% Hispanic, 35% Black and 31% White. Overall, 34% of all undergraduate students were enrolled at community colleges (Juszkiewicz, 2020).

Regardless of background, the goal of these students is overwhelmingly to transfer to a 4-years program and complete their Bachelor's degree. Approximately 80% of community college students report that they intend to earn a Bachelor's degree (Horn and Skomsvold, 2011). However, in reality only 20% earn an Associate's degree and, of those, only 29% transfer to a 4-years institution, (Jenkins and Fink, 2015; Jenkins and Fink, 2016). Just 24% of low-income community college students transfer to 4-years programs compared to 40% of non-low-income students (Juszkiewicz, 2020). Of students who entered community colleges in 2013, only 16.7% overall completed a Bachelor's degree within 6 years and the rate is 13.8% for Hispanic students and 9.9% for Black students. These figures show that a vast majority of community college students do not realize their higher education goals. According to the National Center for Education Statistics (NCES), students from marginalized racial and ethics groups accounted for 41.4% of public community college students in 2018 but only 30.8% of public university students were URM (National Center for Education Statics, 2019b). This attrition continues in the 4-years programs with only 23.6% of all Bachelor's degrees being awarded to URM students in 2017 (National Center for Education Statistics, 2019a).

In 1991, in response to a predicted critical deficit in trained STEM professionals and a lack of diversity in these fields, the National Science Foundation (NSF) initiated the Louis Stokes Alliances for Minority Participation (LSAMP) program to promote and facilitate access to careers in STEM for URM populations. The LSAMP program accomplishes its goal through several best practices based around cultivating a learning community (Tinto, 2003a) that provide academic and emotional support to participants. In New Jersey, there are two LSAMP alliances: Garden State LSAMP (GSLSAMP), initiated in 2009, and Northern New Jersey Bridges to the Baccalaureate (NNJB2B), initiated in 2014. These two consortia form a unique, synergistic collaboration to improve the success, graduation and transfer rate of URM students in STEM using innovative techniques.

It has been suggested that partnerships between universities and community colleges are crucial for enriching the flow of students, especially for URM students (Boggs, 2011; Halpern et al., 2018). Examples of such partnerships include the Tiger Gateway Program to address student college readiness gaps using a summer bridge model (Wilson and Lowry, 2017), the METS/METSTEP program to increase URM participation in Engineering (Anderson-Rowland et al., 2004, 2010, 2013), and the Undergraduate Catalytic Outreach and Research Experiences (UCORE) program that provides a 10-weeks-long summer STEM research residency (Strawn and Livelybrooks, 2012). Although some of these programs involve multiple community colleges, each only includes a single university partner and thus have limited learning communities (Hirst et al., 2014; Halpern et al., 2018).

The interaction between GSLSAMP and NNJB2B is the first attempt at synergistic collaboration between consortia of multiple community colleges and multiple universities with the goal of developing best practices to improve the transfer of URM community college graduates in STEM to 4-years programs. These best practices were developed by GSLSAMP and disseminated to NNJB2B primarily through collaborative activities. The LSAMP program relies on the development of learning communities as a primary best practice (Clewell et al., 2006). The GSLSAMP-NNJB2B collaboration forms a web of interactions that create an expanded learning community (Tinto, 2003a; Tinto 2003b) across multiple institutions at multiple levels. This expanded learning community is the key to the success of this collaboration.

The two alliances have now worked collaboratively for over 6 years, creating a pathway for URM students in STEM from community colleges to 4-years programs. This paper reports on the unique collaboration between GSLSAMP and NNJB2B and the most effective best practices to improve the success, graduation, and transfer rate of URM community college students in STEM fields.

# METHODS

## The Alliances

The GSLSAMP is currently comprised of seven universities and one community college including Essex County College (ECC), Fairleigh Dickinson University (FDU, private institution), Kean University (KU), Montclair State University (MSU), New Jersey Institute of Technology (NJIT, joined in 2019), Rutgers University–New Brunswick (RUNB), Rutgers University–Newark (RUN, lead institution) and William Paterson University (WPU). Bloomfield College was a member of the alliance but left before the formation of NNJB2B. New Jersey City University (NJCU) was also a member from 2009 to 2018 and is included in this analysis. All alliance members are Hispanic Serving Institutions (HSI) except RUNB, and ECC is also a Predominantly Black Institution (PBI). The GSLSAMP achieved its success by experimenting with promising practices at RUN and then disseminating the successful ones to the rest of the alliance. As a result, the number of URM graduates in STEM increased by 156% at RUN over the first 3 years and the GSLSAMP became only the second alliance in LSAMP history to double its number (up 100%) of URM graduates in STEM in less than 5 years. By 2020, the number of URM STEM undergraduate degrees awarded by GSLSAMP schools was nearly quadruple the baseline.

After first being associate members of GSLSAMP, the five community colleges of Northern New Jersey-B2B (NNJB2B) were among the first Bridges to the Baccalaureate alliances in the LSAMP program, commencing in 2014. The alliance originally included Bergen County College (BCC), Hudson County Community College (HCCC), Middlesex County College (MCC), which left the alliance in 2017, Passaic County Community College (PCCC, lead institution) and Union County College (UCC) with County College of Morris (CCM)

**TABLE 1 |** Programs offered each academic year by semester.

| Academic Year | Semester offered | | |
|---|---|---|---|
| | Fall | Spring | Summer |
| 2015 | Annual Conference | Transfer Day | Research Experiences |
| 2016 | Annual Conference | Transfer Day<br>CCPM | Research Experiences<br>CCPM |
| 2017 | Annual Conference | Transfer Day<br>CCPM | Research Experiences |
| 2018 | Annual Conference | Transfer Day<br>CCPM | Research Experiences |
| 2019 | Annual Conference<br>CCPM | Transfer Day<br>sySTEMic<br>CCPM | Research Experiences |
| 2020 | Annual Conference<br>Transfer Admissions Fair<br>CCPM | sySTEMic/YOU GOT THIS!<br>CCPM | Research Experiences (mostly virtual) |
| 2021 (virtual) | Transfer Admissions Fair<br>Speaker Series<br>Observational Research Workshops (Winter Break) | Annual Conference<br>Speaker Series<br>sySTEMic<br>CCPM | Research Experiences (virtual and in-person) |

joining in 2018 for phase II of the alliance. All of the partners are HSI's and lie within the area of northern and central New Jersey served by GSLSAMP. The graduation and transfer data presented here do not include MCC or CCM.

## Joint Programming

The two consortia have maintained a synergistic collaboration for more than 6 years with best practices developed by GSLSAMP being disseminated to NNJB2B largely through collaborative activities. The five most effective interventions are evaluated here. **Table 1** shows when each program was offered.

### Summer Research Experiences for Community College Students

Research opportunities in faculty labs is a priority of GSLSAMP. Typically, more than 250 LSAMP scholars participate in research experiences annually. Community college students are recruited for summer research opportunities by the NNJB2B Coordinators, who screen them for interest and commitment using grades and participation in NNJB2B or GSLSAMP activities. University faculty are recruited to host community college students in their labs or field areas. The students are categorized by area of interest and matched with faculty projects. Faculty are provided with the applications of the NNJB2B scholars and conduct interviews if they choose. Once an arrangement is made, community college students are trained on research protocol and complete lab safety training depending upon the host campus. Once the students and faculty are fully prepared, students begin to conduct research in the lab overseen by faculty, post-doctoral fellows and/or graduate students.

Students placed into faculty labs are awarded research stipends ranging in amount from $1,200 to $2,000. For many students, this amount is sufficient to allow them to forego summer jobs or work fewer hours while learning STEM skills. Students must complete 120 h of research over not more than a 10-week period and submit weekly time sheets signed by both the faculty member and student in order to receive their stipends. Another condition of the stipend is that the students must present their research as a poster at the GSLSAMP/NNJB2B joint annual research conference. The submission of the abstract and preparation of the poster allows additional mentoring opportunities. Presentation of the poster allows the student to take further ownership of the research and provides valuable professional development and networking opportunities.

Research experiences were elevated to a more formal level with the development of a Research Experiences for Undergraduates (REU) at RUN, entitled Dynamic Urban Environmental Science and Sustainability (DUESS). This project leverages the connections and enrollments of the GSLSAMP and NNJB2B for recruitment. The participants are at least 50% community college students and 70% GSLSAMP and NNJB2B students.

### Joint Annual Research Conference

The GSLSAMP/NNJB2B Annual STEM Research Conference is held each fall. As of 2019, this event had grown to 175 presenters and nearly 600 attendees. Due to the shutdown during AY21, the conference was pushed to spring, with 246 students attending virtual. Every student who receives a GSLSAMP or NNJB2B research stipend or participates in the DEUSS REU is required to present their work at this conference. Student researchers prepare and submit an abstract that is published in the conference program. Additionally, students create and present posters of their research helping them to build professional skills such as public oral presentation and communicating their findings to a diverse audience. Development of the posters is done with the oversight of the research mentors. The student presenters talk to attendees and answer questions about their research which provide essential skills.

The conference also benefits students who are not presenting. Seeing the work of their peers offers students role models of what they can accomplish. By bringing together students with similar backgrounds from many different schools, the conference provides students with a STEM identity and an expanded STEM learning community. Additionally, students get to meet and speak with faculty from all the GSLSAMP institutions, providing the opportunity of forming a professional network.

### Annual Transfer Admissions Event

Since the inception of NNJB2B, GSLSAMP has hosted a transfer admissions event. From 2015 through 2019, Transfer Day was held every spring at RUN, with attendance averaging around 100 students each year. Students from each of the NNJB2B schools plus those from ECC of the GSLSAMP were invited to attend. The half-day event included a series of STEM speakers, transfer admissions counselors and representatives from teacher education programs. Information was also provided on the educational requirements for various STEM careers. After the talks, a panel of 4-years GSLSAMP students who transferred from community colleges answered questions. This panel gave the community college students the opportunity to get answers from peer mentors with a related background and experience.

Transfer Day included a Transfer Admissions Fair in which the 2-years students spoke with transfer admissions representatives from each of the GSLSAMP universities. Many schools also sent departmental representatives from STEM fields to answer questions about specific requirements and credits. In October 2019, the Transfer Admissions Fair became part of the Annual Conference's afternoon programming and was held virtually in October 2020.

### Peer Mentoring

The Cross-Campus Peer Mentoring (CCPM) program is intended to enhance the confidence of community college students in transferring to 4-years institutions through peer support and access to essential resources. In the CCPM program, community college students are near-peer mentored by 4-years college students, who, whenever possible, transferred from the same community college as their mentees. The CCPM program was designed to increase the transfer rate by building a larger support and learning community across 2-years and 4-years colleges. The mentor-mentee interactions and peer advising improve mentee confidence in, 1) choosing a major, 2) deciding which 4-years school(s) to apply to, and 3) understanding the steps for successful transfer to their 4-years school of choice.

The initial CCPM experiment was conducted during spring 2016, summer 2016 and spring 2017 semesters. Mentors were GSLSAMP 4-years college students who transferred from the participating NNJB2B community colleges and ECC. Mentees applied through open enrollment at their community college and during GSLSAMP/NNJB2B activities. A total of 200 mentees were recruited. Mentors received $750 and mentees received $50 for completing all requirements of the CCPM program.

The mentors attended a one-day training session. Mentor training included the transfer process, interacting with campus admissions, establishing a relationship with faculty, balancing the rigors of school with personal responsibilities, mentor responsibilities, record keeping and other issues of community college transfer. Mentors received a training manual that explained their responsibilities, effective mentoring skills, confidentiality, appropriate conduct and possible mentor-mentee group or one-on-one activities. Mentor-mentee meet and greet sessions were held at the start of each cohort for mentors to establish relationships with their mentees, and to develop a community among the participants. Mentees had the opportunity to meet their mentors, discuss their major and career goals, and socialize with students from across NNJB2B/GSLSAMP alliances.

Mentors maintained regular communication with their mentees for 10 weeks during the spring 2016 cohort (69 mentees), 4 weeks for the summer 2016 cohort (57 mentees), and 15 weeks for the spring 2017 cohort (61 mentees). Mentors and mentees were required to be in contact at least once per week for a minimum of 30 min, or an equivalent period in texting. Mentees were given a tour of the mentor's college campus, visited research labs, and met other GSLSAMP students. The mentors kept logs of interactions, including time, duration, and mode of communication, which were submitted to the GSLSAMP and NNJB2B campus coordinators.

### Professional Development

Career advisement and professional development occur on each campus of the two alliances through each of the programs offered, both on-campus and across alliances. Students often only recognize STEM opportunities in medical fields, missing the role of STEM in their everyday lives. Speakers are brought in to offer students a different perspective on STEM career options and enlighten students to the possible alternate career paths. In academic year 2021, GSLSAMP and NNJB2B initiated a joint virtual Speaker Series to replace on-campus speaker sessions, which could not take place due to the COVID-19 shutdown. Workshops are offered ranging from GRE and graduate school prep to how to write a résumé, create a LinkedIn page and apply to research opportunities and REUs. These speaker sessions and workshops allow students to improve their professional skills and expand their horizons. Both the research experiences and annual conference also provide a variety of professional development opportunities to students. Two additional, related joint programs: show your STEM innovation challenge (sySTEMic) and YOU GOT THIS! (YGT!) also provide professional development.

Initiated in 2019, sySTEMic is a team STEM innovation competition intended to introduce students to the collaborative nature of STEM, provide them the chance to apply classroom knowledge and show them the opportunities for innovation and entrepreneurship in STEM. Teams of 4–7 GSLSAMP or NNJB2B students are given a real-world issue around which to innovate. Topics have included food waste in the US, plastics in the environment and lack of clean drinking water. Teams have at least 1 month to research the topic and develop an innovation around it, with the help of a faculty mentor. Teams then present their ideas in a 5-min pitch to an audience of their peers and three judges. Each year between 40 and 60 students have participated, with many more attending the presentations.

A larger event, focused specifically on professional development, was envisioned around the sySTEMic presentations. In addition to these presentations, YGT! included a keynote address, individual résumé coaching by the RUN Career Development Center Director and staff, and transfer student panel discussion that had been part of Transfer Day. Moreover, information on summer research opportunities was added, with professors from MSU, NJIT, RUNB, and RUN in attendance, as well as the PI of every REU offered in New Jersey and the Director of University of Pennsylvania's Summer Undergraduate Internship Program, providing a valuable mentoring and networking opportunities. Time and space were also reserved for participants of the CCPM program to meet with their mentors in person. Unfortunately, this event was only held once prior to the COVID shutdown although plans are to continue it when in-person events are again allowed.

## Student Evaluation of Programming

Both GSLSAMP and NNJB2B employ the SageFox Consulting Group as their evaluator, allowing comparison across alliances and programming. Students who attend any GSLSAMP/NNJB2B joint program or event are asked to complete assessment surveys. A standardized survey was developed to make comparison across events and across years possible. In brief, students provide their school, demographic information, the impact of the event/ program on their educational and career aspirations, the best part of the programming and possible improvements. Students are asked what the highest level of education they intend to attain both pre- and post-event/program.

To evaluate the impact of the CCPM program, formative evaluations were administered to the mentees in spring 2016 and summer 2016, a benchmark evaluation was administered in spring 2017, and summative evaluations were administered all three semesters. In addition to requesting demographic information, these evaluations included self-assessments of students' confidence in their ability to successfully transfer to a 4-years school. Additionally, spring 2016 and summer 2016 mentees were monitored to determine the number of students that graduated and transferred to a 4-years university.

## Graduation and Transfers-Out Data

Graduation and transfer-out data are measures of the success of NNJB2B, which is required to reported these data annually to NSF. The data are obtained from each school's institutional research office and compiled by the NNJB2B Program Director for each academic year. For the years 2012 (baseline), 2015, 2016, 2017 and 2018, alliance data includes BCC, HCCC, PCCC and UCC. For years 2019 and 2020, BCC left the alliance and CCM joined. Since MCC left the alliance mid-phase, its data are not included.

Graduation data were obtained for NNJB2B (**Supplementary Table S1**) were compared to data for all public New Jersey 2-years colleges (NJCC, n = 19) and for all public 2-years colleges in the United States (USCC, n = 924). These data were obtained from the Integrated Postsecondary Education Data System (IPEDS) of the U.S. Department of Education (https://nces.ed.gov/ipeds/use-the-data). Data submission to IPEDS is required for any institution that participates in any federal financial assistance program, with data collected annually in Fall, Winter and Spring. All IPEDS gradation data were obtained from "Graduation Rate" in "Survey Data" for URM students awarded Associates degrees in NSF-approved STEM majors, by Classification of Instructional Programs (CIP, https://www.lsamp.org/help/help_stem_cip.cfm), during the academic years 2012 (baseline) and 2015-2019. The 2020 data were not yet available on the IPEDS site.

The Transfers-Out data from IPEDS were not filterable by major so data for NNJB2B were those reported to NSF for URM students in STEM majors (**Supplementary Table S2**). These were compared to the transfers-out data for NJCC and USCC for URM students in all majors obtained from "Completions" in "Survey Data" on the IPEDS site.

## Transfers-In Data

To assess the impact of the NNJB2B on transfers into the seven GSLSAMP universities, each was asked to provide institutional data for 2012 and from 2014 to 2018, broken down by race/ ethnicity, with the following criteria (**Supplementary Table S3**):

1) New Undergraduate, Degree-Seeking Transfer Students From BCC, HCCC, PCCC and UCC
2) enrolled in a STEM field for their first or second major (not minor) using NSF STEM categories
3) Full or Part-Time Enrollment

The data on transfers between NNJB2B and GSLSAMP were compared to the IPEDS data for URM STEM students who transferred into non-religious New Jersey 4-years colleges and universities (NJUniv, n = 30). as well as into non-religious US 4-years colleges and universities (USUniv, n = 1,429). IPEDS data were obtained from "Fall Enrollment" in "Survey Data" available through the public website (https://nces.ed.gov/ipeds/use-the-data). These data were obtained for 2012, 2014, 2016 and 2018 because major field of study data are only available for even years. These data are not yet available for 2020 on the IPEDS site.

# RESULTS

Students who attend GSLSAMP and NNJB2B programs and events provide evaluations of the programming. These evaluations are collected via surveys administered since 2016 by SageFox Consulting Group the external evaluator of GSLSAMP and NNJB2B. This commonality in evaluator facilitates comparison across events and years. When each program was offered is shown in **Table 1**.

## Research Experiences for Community College Students

External evaluation shows that research experiences are the powerful tool in encouraging NNJB2B community college students to transfer to a 4-years program. 93% of responding

NNJB2B students opined that research experiences made them interested in continuing to do research and 71% said it made them want to continue to pursue higher education in STEM. Using a 4-point Likert scale, where 4.0 is "benefited to a great extent", students assessed research experiences at 3.8, 3.6 and 4.0 for 2016 (n = 161), 2017 (n = 91) and 2018 (n = 81), respectively.

Some students provided written comments describing the main benefit of their research experience. Statements included:

The fact that I could spend my summer working in a lab with a professor of my choosing was my dream becoming reality (2016)

Being able to enter undergraduate research and develop a strong transfer plan (2016)

The main benefit of my whole research experience was the amount of exposure I received in Rutgers University. I interned there from Summer 2016 until the end of Spring 2017, accomplishing many independent tasks such as creating and presenting my own poster and research at two different conferences. I am also looking forwards to publishing my own academic paper and have seen the appeal of the research world, changing my goals from attending a veterinarian school to enrolling into a graduate school in a specialized field under the wide umbrella of Biology (2017)

The paid research gave me the opportunity to get real life experience and to [learn] outside of the classroom. It also allowed me to gain a lot of knowledge (2017)

Starting research earlier than most other undergraduate students, being able to pay for my own tuition with stipend and entering professional sciences (2017)

I learned how to conduct research and help me to apply to other competitive research opportunities. Furthermore, it helps me to get a variety of scholarships (2018)

Some of the benefits [of B2B-supported research] are getting paid to do work while acquiring knowledge that pertain (sic) to my field of study, networking with faculty and other students, and it helps us develop a sense of what happens in a work environment (2018)

## GSLSAMP/NNJB2B Annual STEM Research Conference

The Annual STEM Research Conference has been held each October since the inception of GSLSAMP and has included NNJB2B since 2014. The student surveys consistently show the very valuable aspects of the event. For 2015, 2016, 2017 and 2018, two of the highest ranked aspects, on a 3-point Likert scale, were: 1) receiving feedback on their posters (2.69 (n = 55), 2.15 (n = 55), 2.74 (n = 106), 2.71 (n = 62), and 2.66 (n = 84) for 2015, 2016, 2017, 2018 and 2021, respectively, on a 3.0 Likert scale); and 2) seeing other students' posters (2.78 (n = 89), 2.66 (n = 123), 2.82 (n = 167), 2.70 (n = 90) and 2.72 (n = 84), respectively). In 2019 (n = 171), a 4.0 Likert scale was used with students rating presenting their research at 3.41 and seeing others' posters at 3.51. In 2019, the average rating of the conference overall was 4.55 (n = 122) with 5.0 indicating Excellent. These opinions can be seen clearly in the comments of some students:

[The best thing about the conference this year was] the encouragement I received. It helps me realize that I, too, can be successful (2015)

[The best thing was] getting experience and connections in the field I'm getting my degree in. Getting presentation experience to prepare me for future jobs (2015)

The program really encouraged me to pursue my goals of becoming a physicist. I had the opportunity to talk to experts on my field and [it] help[ed] me answer my doubts (2016)

The best thing was that many of the faculty were enthusiastic about offering help and interested in staying in touch (2018)

I had a really deep conversation with one of the poster presenters and she was a senior. I am a sophomore, and she really guide me towards applying for research through LSAMP (2018)

It was amazing to see the hard work and dedication the students put into their research. I want to be part of that research community of great thinkers (2019)

It was mostly valuable to me because for the first time I felt like I belonged among this group. The way my peers' faces lightened, talking about their interests was absolutely rewarding (2019)

[The keynote address] helped me realize that all of us have struggled at some point and experienced imposter syndrome (2021)

## Transfer Day and Transfer Admissions Fair

Transfer Day created a pipeline from the 2-years programs of NNJB2B to the 4-years programs of GSLSAMP. Student evaluations were administered each year and responses numbered 45 in 2017, 28 in 2018, and 36 in 2019. In each of these years, on a 5-point Likert scale in which 5 is very valuable and one is not valuable at all, the event was considered very valuable with scores of 4.6, 4.8 and 4.8, respectively (n = 45, 28 and 36, as mentioned above). Although the Transfer Admissions Fair was held virtually in October 2020, with 41 students attending, the survey response rate was very low (n = 5) so is not included here.

In 2017, 2018 and 2019, the post-event survey found that the majority of respondents had 30 or more credits (82, 64 and 74%, respectively) and nearly all indicated they intended to transfer to a 4-years program (98, 93 and 93%, respectively).

Students reported the most cited barrier to transferring as cost. In 2017, 2018 and 2019, respectively, 87, 86, and 81% of student survey respondents reported that finances would make it difficult to for them to transfer to a 4-years program. GPA was the next most common obstacle cited (31, 25 and 22% in 2017, 2018 and 2019, respectively) but not nearly to the extent of finances. When further asked what information or service would be helpful to them in preparing to transfer, student consistently indicated mentorship as the most important (78, 86 and 69% in 2017, 2018 and 2019, respectively) followed closely by financial workshops (76, 71 and 64%, respectively) and help with academic skills (62, 68 and 67%, respectively).

Students found the transfer admissions fair and the transfer student panel discussion to be the most impactful. These were repeatedly mentioned as the most valuable thing learned and the best part of the event. A sample of the written statements include:

Listening to the mentor panel. It's always great to hear from those who are just like you (2017)

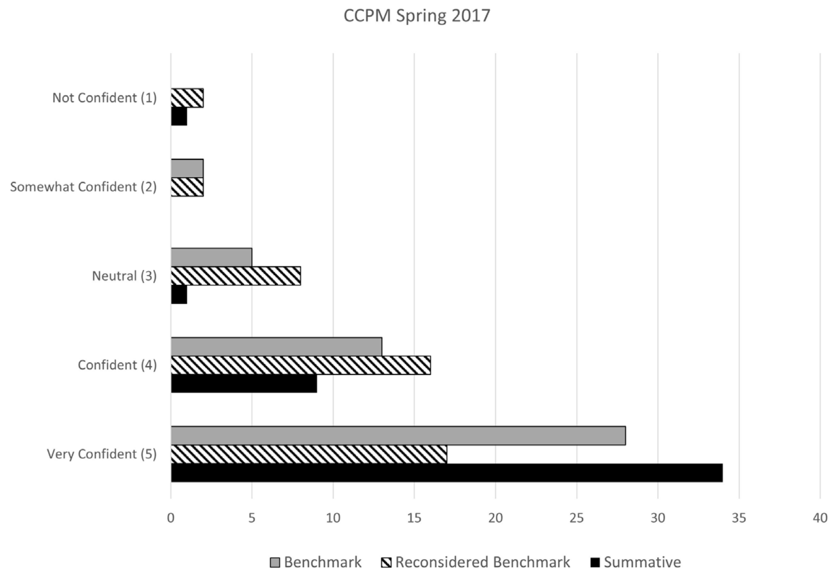


**FIGURE 1 |** CCPM Spring 2017 Cohort Survey Responses.

There is so much opportunity out there and I need to be a part of that (2017)

Feeling there's hope and it's not that difficult to transfer and there's help along the way (2017)

The most valuable thing I learned at the Transfer Day Event was to take advantage of opportunities (2018)

That I was able to see students that have succeeded, so that show [s] me that I can do it too (2018)

I learned that Ph.D. programs are more flexible than what I believed them to be (2019)

My experience with things like guilt, imposter syndrome, and family responsibilities have made me feel very isolated from peers my age, but [the keynote] address made me feel seen, understood, and hopeful about the future (2019)

## Cross-Campus Peer Mentoring (CCPM)

As described by Smart and Gates (2018), formative evaluations were administered in spring 2016 and summer 2016. The spring 2016 formative data found that 53% of 69 mentees who completed the program felt confident in transferring. In comparison, summative evaluations at the end of spring 2016 showed that 92% of mentees felt confident in transferring, an increase of 39%. The summer 2016 formative evaluation found that 62.1% of the 57 mentees were confident in transferring in comparison to 89.1% of mentees feeling confident in transferring in the summative evaluation. This is an approximate increase of 27%. In spring 2017, benchmark evaluations showed that 73% of 61 mentees reported confidence in transferring to a 4-years college whereas 95.5% of mentees were confident in transferring in summative evaluations (**Figure 1**).

Pairing mentees with near-peer mentors who shared common experiences played a critical role in this program. Evaluations showed that the mentees felt that the top benefits of CCPM included, 1) working with a mentor who shared the same experience, 2) developing a strong understanding of the transfer process and 3) gaining knowledge about STEM academic programs and majors.

Spring 2016 and summer 2016 mentees were monitored to determine the number of students to graduate and transfer a 4-years university. By 2018, 97.6% of the Spring 2016 mentees had transferred to a 4-years institution and of those 62.3% graduated. Similarly, 94.5% of the Summer 2016 mentees had transferred to a 4-years institution and of those 64.9% graduated (Smart and Gates, 2018). This is 60.9–64.0% greater than the 2016 national average transfer-with-award rate of 33.6% and 47.5–50.6% greater than the 2016 New Jersey public community college average transfer-with-award rate of 47.0% (Shapiro et al., 2017). Additionally, the rate of transfer of participants of CCPM was 44.4-41.3% greater than the 53.2% of NNJB2B graduates who transferred in 2016 (Smart and Gates, 2018). These results shows that CCPM is a best practice in enhancing student confidence in transferring.

## sySTEMic/YOU GOT THIS (YGT!)

In a survey of the 2019 sySTEMic participants, respondents (n = 29) indicated that, on a 3-point Likert scale where three is "very valuable," the event was assessed as very valuable for showing students creating a plan of action (2.8), researching a solution (2.8), working with a team of students (2.9) and pitching the solution (2.8). Getting a better idea of entrepreneurship was also seen as valuable, with an average rating of 2.6. Both sySTEMic team members and students in the audience were asked to assess the sySTEMic presentations. In 2019 (n = 36), they were given a 4.5 on a 5-point Likert scale (5 = very valuable) and in 2020 (n = 54), a 4.7. When students were asked the most valuable thing learned from the presentations, several indicated sySTEMic had made a profound impact.

Being able to innovate an idea and bring seven minds together.

Being a part of a team and being supported by faculty.

**TABLE 2 |** Degree plans before and after YGT!.

| Degree | All respondents (n = 54) | | Community college (n = 33) | | Four-year school (n = 21) | |
|---|---|---|---|---|---|---|
| | Before | After | Before | After | Before | After |
| Associate's | 7% | 4% | 12% | 6% | - | - |
| Bachelor's | 24% | 13% | 24% | 9% | 24% | 19% |
| Master's or MD | 44% | 43% | 39% | 42% | 52% | 43% |
| PhD | 24% | 37% | 24% | 36% | 24% | 38% |

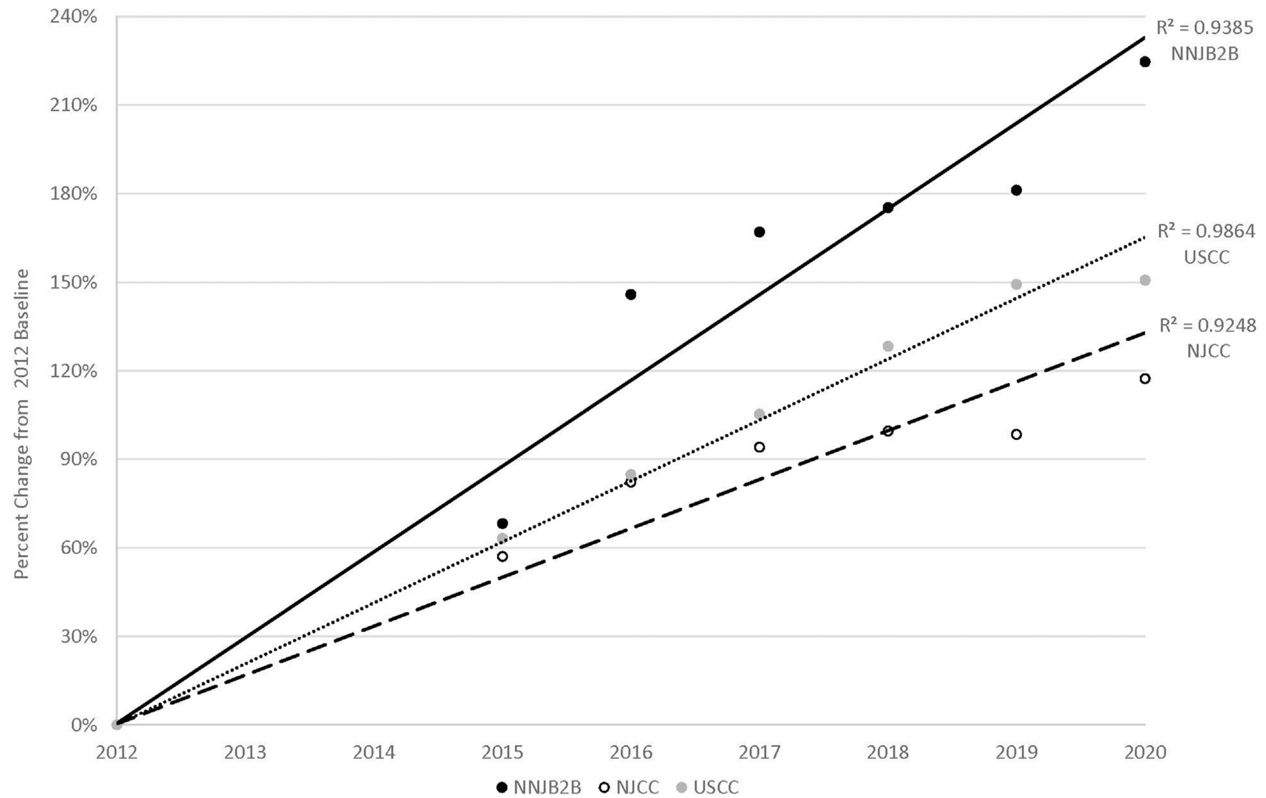


**FIGURE 2 |** Associates Degrees awarded to URM students in STEM fields at NNJB2B and at all community collegues in New Jersey (NJCC, n = 19) and in the United States (USCC, n = 924) as reported to IPEDS. Data shown as percent increase from the 2012 baseline.

The ability to innovate and combine creativity with science.

Creating a project; there was a lot of work, ideas, teamwork, and fun.

Everything in this world can be a research topic and can be made better.

[I] found ways in which I could apply my major, computer science, into the field of biology and biochemistry.

This is the first time that I work with an interdisciplinary group and I learned that our backgrounds, knowledge and experiences are powerful weapons to impact the world.

Of the other offerings at YGT!, all were seen as very valuable by the survey respondents (n = 54), with nearly 89% seeing value in the resume guidance (4.7 rating on a 5.0 scale), 94% seeing value in speaking to professors about research opportunities (4.8 rating) and 96% expressing value in the event overall (4.7 rating). Additionally, 50% of the respondents met with their CCPM mentors and 31% indicated they were considering new academic or career options as a result of YGT! (**Table 2**).

## NNJB2B Graduation and Transfers-Out

For the years 2012-2018, only four of the original five community colleges of NNJB2B were included in this analysis: BCC, HCCC, PCCC and UCC, while all four phase II colleges were included for 2019 and 2020 (CCM, HCCC, PCCC, UCC). In the NNJB2B grant proposal, data from 2012 were used as a baseline. Data from each year after funding were normalized to these figures and expressed as a percent change from this baseline.

In 2015, Year one of NNJB2B, the number of URM STEM graduates was at 68.2% above the 2012 baseline. This upward trend continued, with the number of URM STEM graduates reaching 145.9, 167.1 and 175.3% over the 2012 baseline in 2016, 2017 and 2018, respectively. By 2020, the number of URM STEM

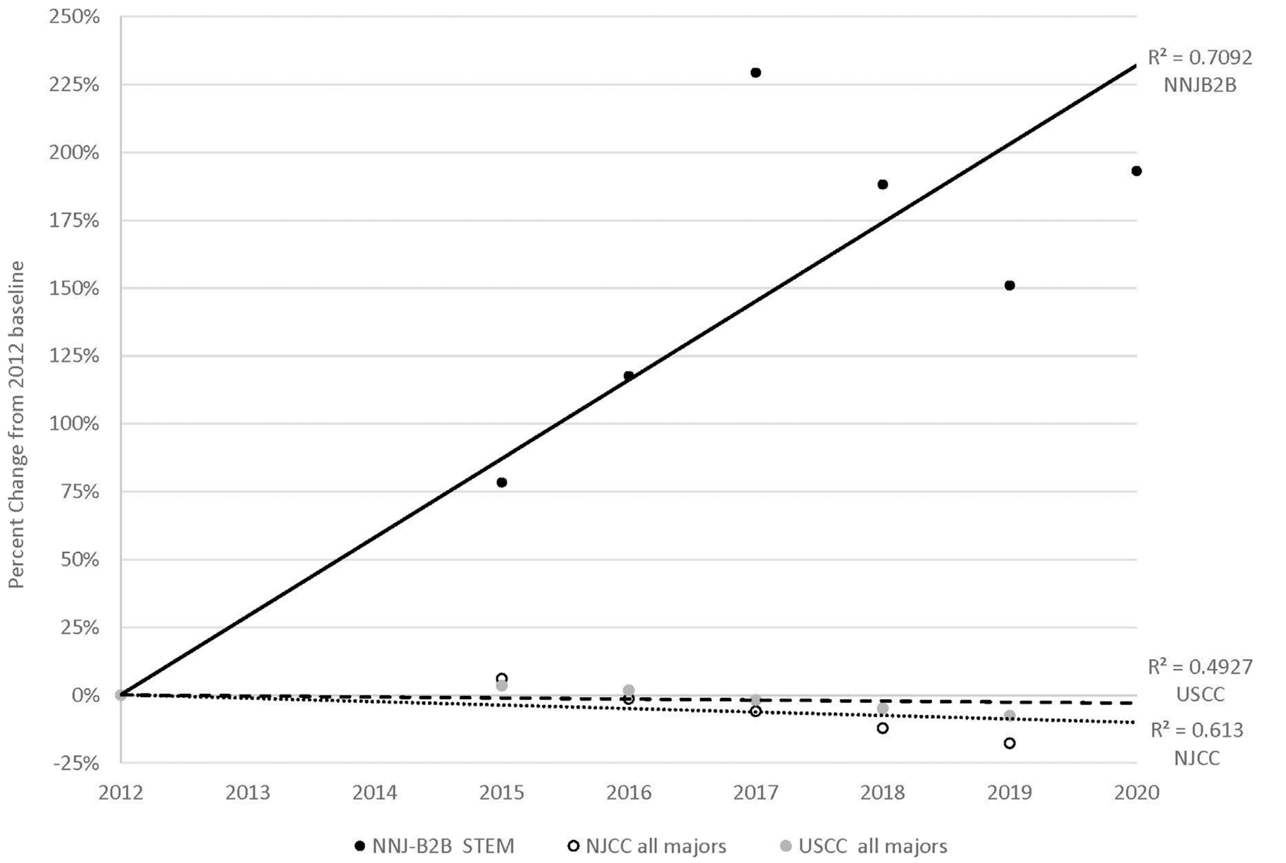


**FIGURE 3 |** Comparison of URM transfers out in STEM majors from the NNJB2B schools and in all majors from all community colleges in New Jersey (NJCC, n = 19) and in the United States (USCC, n = 924) as reported to IPEDS. Data shown as percent change from the 2021 baseline. (IPEDS data for "Transfers-Out not available for 2020.)

graduates from the NNJB2B schools was 225% above the 2012 baseline, nearly double the increase for all New Jersey public community colleges (NJCC, n = 19) of 117% and half again as great as the increase for all United States public community colleges (USCC, n = 924) of 151% (**Figure 2**). As an annual percent change, the number of NNJB2B URM STEM graduates increase, on average, 24% each year, substantially higher than the average increases for NJCC (15%) and USCC (18%).

Since the inception of NNJB2B, the number of graduated students who transfer-out to 4-years programs has increased to over 150% above the 2012 baseline, reaching a high of 229% over the baseline in 2017. This significantly exceeds the transfers-out from all NJCC, which experienced an overall decrease of nearly 18% in transfers-with-award from 2012 to 2019. The average for all public 2-years colleges in the US (USCC) closely followed the NJCC trend (**Figure 3**), with a reduction in transfers-out of nearly 8%. It is important to note that NNJB2B data includes only URM students in STEM fields whereas NJCC and USCC data includes URM students in all majors at all public 2-years schools.

NNJB2B experienced an average annual increase in transfers-out of 31% compared to the prior year. During this same period, the average annual change in transfers-with-award for NJCC decreased (−4% annually, on average). This trend was also occurred for USCC, with an average decrease in transfers-with-award of 1% each year.

## GSLSAMP Transfers-In

From 2012 to 2018, GSLSAMP universities experienced a significant increase in URM STEM transfers-in from NNJB2B schools (57%). However, not all of the GSLSAMP universities participated in the programming to the same extent. Several did not provide CCPM mentors, host NNJB2B research experiences, provide faculty speakers or send representatives to joint events. As a result, there were differences in their success in building a pipeline with the NNJB2B alliance. Four universities were particularly involved in this programming, including FDU, KU, MSU and RUN, all consistently providing peer mentors, student ambassadors, faculty speakers, research opportunities and admissions representatives. As a result, these institutions experienced the greatest increase in NNJB2B transfers-in, with an increase of 63% over the 2012 baseline. During the same period, NJ public and non-religious, not-for-profit private universities (NJUniv, n = 30) experienced an increase of 30% above the 2012 baseline and US public and non-religious, not-for-profit private

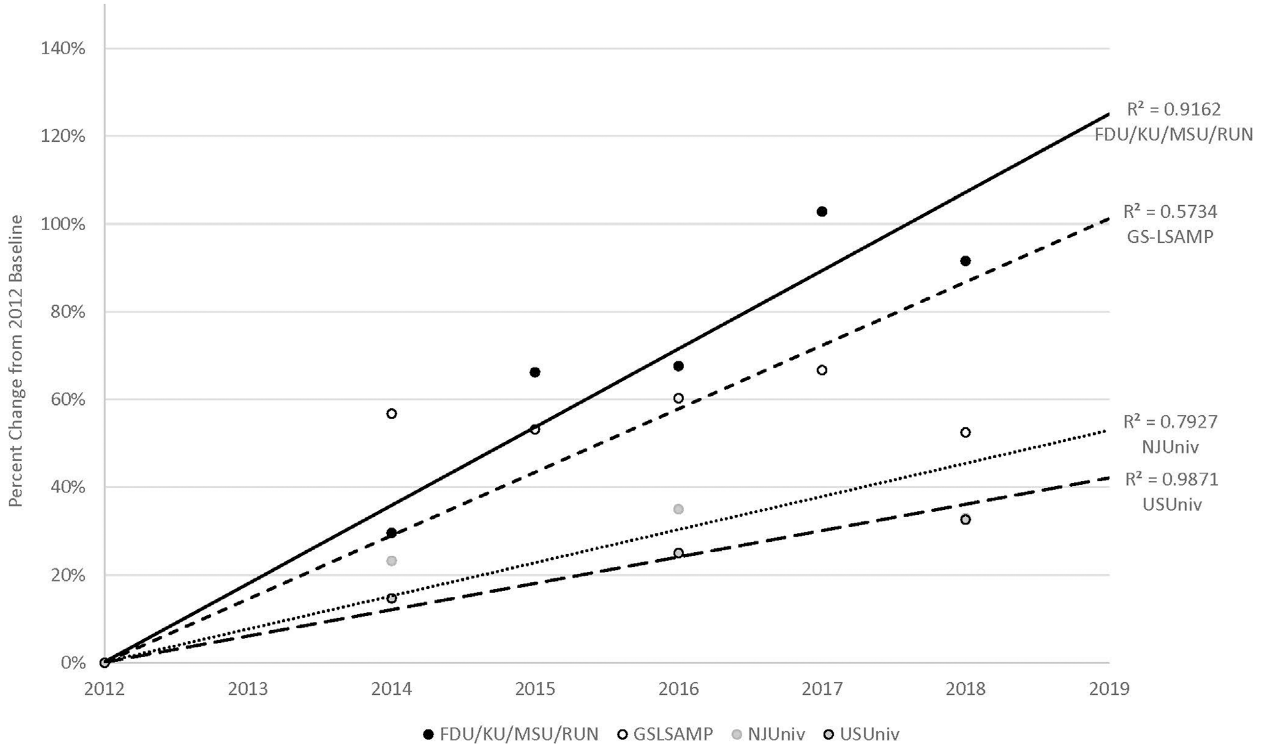


**FIGURE 4 |** URM STEM Transfer-In students from NNJB2B to four of the GSLSAMP schools (Fairleigh Dickinson University, Kean University, Montclair State University and Rutgers University-Newark) versus URM STEM Transfer-In students from all public 2-year schools to all non-religious 4-year schools in New Jersey (NJUniv, n = 30) and in the United States (USUniv, n = 1429) as reported to IPEDS. Data shown as percent increase from the 2012 baseline, (IPEDS data for field of study are only available for even years only.)

universities (USUniv, n = 1,429) experienced an increase of 24% above the 2012 baseline (**Figure 4**). These transfer-in numbers refer to URM students in STEM majors only. This means that participation in cross alliance collaborative programming increased transfers-in of URM community college graduates in STEM by more than 25% over the state and national averages. The percent change in these URM STEM transfers-in from NNJB2B to GSLSAMP increased an average of 18% biannually while transfers-in from NNJB2B to the FDU, KU, MSU, RUN participatory group increased an average of 24% biannually. In comparison, URM STEM transfers-in to NJUniv and USUniv each increased by only 10% biannually, on average.

## DISCUSSION

The vertical transfer from 2-years to 4-years programs serves as a vital pathway to upward mobility for many URM students (Jenkins and Fink, 2015). Community colleges serve as "a key gateway" for URM students into higher education, with nearly half of all Hispanic and African American college students enrolled in them (Crisp and Nuñez, 2014). Solid relationships between community colleges and universities provide students with opportunities for academic and social integration (Townsend and Wilson, 2006; Jenkins and Fink, 2016). There are many examples of programs between 4-years and 2-years colleges and universities that enhance the graduation and transfer rate of the community college students (see, for example, Yomtov et al., 2017; Halpern et al., 2018). However, the relationship between the GSLSAMP and NNJB2B involves the synergistic collaboration between two alliances to improve the success of URM community college students on a regional, rather than institutional, scale. The events and programming were developed based on experimentation and dissemination within the project coupled with research-based best practices. This method has realized significant results.

The main approach to the interacting consortia is to develop an extended learning community (Tinto, 2003a; Tinto 2003b). The LSAMP program relies on the development of learning communities as a primary best practice (Clewell et al., 2006). These learning communities are primarily within single institutions. Collaborations between 2-years and 4-years programs involve limited learning communities across the two institutions (Hirst et al., 2014; Halpern et al., 2018) or a few community colleges and one university (Anderson-Rowland et al., 2004, 2010, 2013; Strawn and Livelybrooks, 2012). However, the GSLSAMP-NNJB2B collaboration is far more extensive, forming a web of interactions that create an expanded learning community across multiple institutions at multiple levels. This expanded learning community is the key to making this collaboration synergistic. All participating students and institutions benefit.

The success of the synergistic collaboration between GSLSAMP and NNJB2B is documented in the markedly improved graduation, transfers-out and transfers-in rates. The number of URM STEM students graduating from NNJB2B schools has been increasing by nearly 30% annually, almost double the NJCC rate and more than double USCC rate. Of the NNJB2B graduates, nearly 35% more transferred to 4-years programs each year. This is in sharp contrast to the transfer rate for all majors in both NJCC and USCC, which are declining. GSLSAMP institutions had a substantial increase in URM STEM transfers-in from NNJB2B during this collaboration. Compared to URM STEM transfers-in from all sources to NJUniv and USUniv, the annual percent increase was more than double. This shows that not only is the joint programming effective, the two alliances have built a pipeline for URM STEM students from community college to universities.

Another explanation for the overwhelming success of the collaboration of these consortia is that the programming forms a closed loop, with each program directing students back to others, thereby reenforcing participation. For example, YGT! can point students to many other opportunities. A student can find research opportunities and receive faculty mentoring and professional skills development. This then leads to the annual conference, which provides additional professional skills, networking opportunities and admissions information, leading to transfer or graduate school. Another student at YGT! might hear about CCPM and sign up to participate, which will increase that student's confidence in transfer and open the possibility of research and all the benefits just mentioned. Yet another student at YGT! might be presenting a sySTEMic innovation which can lead them to other professional development and/or research opportunities, leading to more faculty mentoring, the annual conference, the admissions fair and transfer.

Through the collaboration, NNJB2B students are exposed to the best practices for academic and social support of the GSLSAMP. They are also given the opportunity to have an introduction to a 4-years campus, establish peer and faculty mentor relationships, build their professional skills, and expand their potential in STEM. Both NNJB2B and GSLSAMP students conduct and present research at the joint annual conference, providing them with professional development skills. Additionally, being exposed to their peers' work provides both researcher and non-researcher students with mentors and role models for what they can accomplish, thereby showing students they have a place in STEM. By bringing together students with similar backgrounds but from many different schools, the annual research conference exemplifies the expanded STEM learning community.

Providing research experiences is a recognized best practice and a primary focus of the GSLSAMP/NNJB2B collaboration. Research opportunities promote students' scholarly development and independence and provide personalized education as well as connections with faculty. This has been found to be especially important to URM students across all academic disciplines and at a wide variety of institutions (Elgren and Hensel, 2006). Early research experiences have been shown to improve retention and students can develop personal and professional skills through multiyear research programs (Thiry et al., 2012; Carrero-Martinez, 2011; Grabowski et al., 2008). This also provides the opportunity to mentor newer students in the lab which has been correlated to persistence in research careers (Chang et al., 2014). Alexander et al. (2007) found that finances were often a barrier for Hispanic students who wished to continue their educations. As noted in the student comments, for students who must generate income over the summer, either to pay for their schooling or to assist their families, research stipends can provide this income, in part or in whole, while allowing them to gain valuable STEM skills and build their STEM identities.

Peer mentoring has been found to alleviate social pressures, provide an environment that addresses challenges of URM students, ease student transition into the college environment, and promote coping skills and resiliency (Lisberg and Woods, 2018). Mentoring within a single campus has proven to support both graduation and transfer rates (Yomtov et al., 2017). Additionally, mentoring of high school students by college business majors was found to increase the high school students perceived level of college success and their level of comfort on a college campus (Luczuk and Kalbag, 2018). However, CCPM shows the impact of peer mentoring across 2-years and 4-years institutions (Smart and Gates, 2018). CCPM is a transformative model centered on theoretical premises of motivational constructs to enhance student confidence and self-efficacy. Based on Bandura (1977), CCPM mentors help to build mentee identity as a student capable of transferring. CCPM not only provides mentees with a roadmap for transferring, but also allows students to explore the institution to which they are considering transfer. Based on Bandura (1986), "modeling," is an effective technique to teach general rules and strategies for dealing with different situations. Pairing 2-years student mentees with 4-years student mentors who share common major(s) and life experiences, including transferring themselves, plays a critical role in this program. Peer mentors are key in CCPM because they demonstrate that transferring to and succeeding in a university setting is a realistic and attainable goal.

Multiple studies show that professional development is transformative in URM STEM education and student success, both at the undergraduate and graduate levels (National Research Council, 2011; Moreira et al., 2019). Neiles and Mertz (2020) define professional skills as non-technical skills important to being an effective scientist, including resume writing and networking, problem solving and big picture thinking, scientific identity development, initiative, communication skills, and interpersonal skills such as teamwork and leadership development. Every one of the enrichments described here have an aspect of professional development, including initiative, teamwork and STEM identity development and networking in research experiences, communication skills, networking and STEM identity development in the annual conference, leadership and communication skills development in CCPM, and networking, resume writing and STEM identity development in Transfer Day. Wright et al. (2019) also included entrepreneurship as an important part of STEM professional development. The sySTEMic and YGT! events cover this aspect of professional development as well as every single aspect other aspect mentioned above while also including both peer and faculty mentoring components.

The National Research Council (2011) identified areas that must be addressed to increase the success of URM students in STEM fields, including summer research programs and experiences, professional development, academic support, and social integration and mentoring. All of these areas are addressed in the collaborative programming of GSLSAMP and NNJB2B. This cross-alliance programming is greatly facilitated by the population density and proximity of alliance institutions in northern and central New Jersey. Replication of the synergism described here may be limited elsewhere by proximity. However, given the magnitude of the results, implementation on any scale would likely be beneficial. With the COVID-19 pandemic, student retention is even more critical. Johnson and Cuellar Mejia, 2020 state that the number of students transferring may plummet citing a survey by Education Trust West, which found that 75 percent of California students were worried about staying on track due to the virus. Now, more than ever, URM STEM students need support programs like those described here.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by ArtSci Institutional Review Board, Rutgers University - Newark. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

AG contributed to conception and design of the study. CSM collected the data, performed the statistical analysis. and wrote the first draft of the manuscript. AG wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.679865/full#supplementary-material.

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# Developing Self-Efficacy and Behavioral Intentions Among Underrepresented Students in STEM: The Role of Active Learning

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Increasing academic participation among students from ethnic-racial underrepresented groups in STEM yields societal benefits including ameliorating economic ramifications of the labor shortages in STEM, improving scientific innovation, and providing opportunity, access, and participation in high-status STEM fields. Two longitudinal studies with students from underrepresented groups investigated the role of active learning interventions in the development of STEM self-efficacy and intentions to pursue STEM in the future. Study 1 longitudinally tracked high school students participating in a 4-week geoscience program that applied active learning techniques ranging from hands on experiments to peer discussion. High school student participants displayed increases in self-efficacy and STEM intentions from the start to completion of the program, an effect that was observed exclusively among those who reported strong program quality. Study 2 examined the role of mentorship effectiveness with a sample of community college STEM students interested in transferring to a 4-year college. Students' relatively strong self-efficacy and STEM intentions at the start of the semester remained stable through the end of the semester. Altogether, the present research highlights the role of positive, inclusive educational climates in promoting STEM success among students from underrepresented group members.

**Keywords: STEM interventions, minorities, mentorship, educational climate, STEM education, high school, community college (Min5-Max 8)**

## INTRODUCTION

Among all students who enter college with intent to pursue STEM, only 43% of Latinx and 34% of Black students earn a STEM degree, compared to 58% of White students (Riegle-Crumb et al., 2019). Indeed, ethnic-racial identification is the strongest predictor of who leaves STEM during college, above and beyond other relevant characteristics such as gender and socio-economic status (Shaw and Barbuti, 2010). The relatively high STEM attrition among students who identify with underrepresented groups (URGs; Black, Latinx, Native American, and women) is caused in part by relatively unwelcoming atmospheres that impair URG confidence and undermine STEM intentions (Seymour and Hewitt, 1997). Similarly, the numeric underrepresentation of individuals from URGs in STEM creates cultural stereotypes that link STEM competence to White and Asian men (Miller et al., 2015; Eaton et al., 2020), which make stigmatized identities

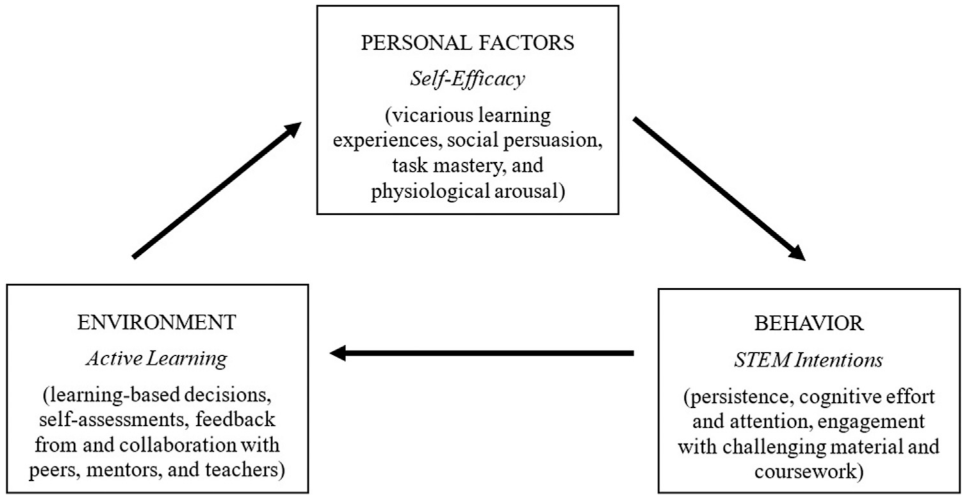


**FIGURE 1 |** Bandura (1978) model of triadic reciprocality applied to STEM environments, personal factors, and STEM intentions.

salient in STEM classrooms (Cheryan et al., 2015), especially under testing circumstances (Steele, 1997). Finally, stereotype activation impairs performance (Spencer et al., 2016), diminishes personal belief in the ability to succeed (self-efficacy) in a stereotyped domain (Dasgupta, 2011), and drives academic isolation (Swarat et al., 2004). To address the barriers that affect STEM attrition among URGs, researchers are seeking to identify which STEM education settings are conducive for URG success and why.

Active learning strategies counter challenges associated with URG numeric underrepresentation in STEM education settings by facilitating collaborative, inclusive, and self-efficacious learning environments (Theobald et al., 2020). Furthermore, active learning strategies prepare students and trainees for the flexible thinking required among most contemporary careers (Ahmad, 2019; Hesketh, 1997). Indeed, implementing more active learning strategies in STEM education increases URG participation in STEM careers, which in turn promotes United States economic competitiveness by improving innovation through increased diversity of thought (Richard, 2000; Lee and Buxton, 2010). The present research couches active learning within Bandura (1978) triadic reciprocality among the environment, personal factors, and behavior. As displayed in **Figure 1**, and discussed below, positive educational climates, self-efficacy, and intentions to persist in STEM are all inextricably linked (Nauta et al., 1998; Nauta et al., 2002; Vogt, 2008; Zeldin et al., 2008; Byars-Winston et al., 2010). Positive educational climates adopt active learning and are supportive and inclusive, thus promoting student dignity and feelings of agency over their learning (Thapa et al., 2012). These factors are theorized to disproportionately benefit URG students' self-efficacy and intentions to persist in STEM (Seymour and Hewitt, 1997). We test these components and their interrelations across two longitudinal STEM intervention studies with URG high school and community college students.

## Active Learning

Learning STEM material via traditional, passive classroom settings is historically popular in the United States (Wise, 1996), but active learning and its processes and benefits are unparalleled, including in STEM (for a review, see Ishiyama, 2013; for a meta-analyses, see Freeman et al., 2014; Schroeder et al., 2007). Active learning strategies are rooted in constructivist theories of learning that position the learner in control of their own knowledge acquisition, compared to the traditional teacher-student transmission of knowledge referred to as "teaching by telling" (Ivancic and Hesketh, 1995; Smith et al., 1997). Instead of placing the responsibility for learning-based decisions on an external source, typically the teacher, the learner oversees choosing information to process while monitoring physiological arousal including regulating one's stress response during the learning process (Iran-Nejad, 1990). Active learning requires exploration and experimentation with a goal to develop domain specific skills (Ishiyama, 2013). Though active learning entails a wide breadth of potential activities that can be incorporated inside or outside of traditional classrooms, the central goal is for the learner to be in control of the learning process to create flexible and adaptive thinking.

Research on educational climates and applied STEM coursework also support the benefits of active over passive learning environments (McNeil, 2000; Thapa et al., 2012; Sublett, and Plasman, 2017). Educational climate research emphasizes that students experience superior short-term and long-term outcomes when embedded in supportive, cooperative, and respectful educational environments, where students are encouraged to actively participate in the learning process (Thapa et al., 2012). Research on applied STEM courses highlight how hands-on learning opportunities help contextualize more abstract STEM concepts in real-world settings, which promote academic engagement and reduces anxiety (Bozick et al., 2014; Sublett, and Plasman, 2017).

Finally, a meta-analysis of 225 studies that directly compared the performance of students participating in active versus passive (traditional) STEM courses showed that not only does active learning significantly improve student performance, students in active learning settings were 1.5 times more likely to pass STEM courses (Freeman et al., 2014).

Another factor central to active learning environments is an inclusive and respectful community of peers, mentors, and teachers (Theobald et al., 2020). Active learning environments characterized by a "culture of inclusion" close achievement gaps between URG and non-URG students in STEM, because they provide dignity, collaboration, and communication of confidence in student ability (Theobald et al., 2020). Engaging with peers on relevant material improves performance, retention, and critical thinking (Stefanou, and Salisbury-Glennon, 2002; Kudish et al., 2016). For example, small group interactions in a traditional lecture hall gateway course increased performance and retention of Black students in STEM, compared to Black students who participated in a control group (Treisman, 1992). Discussing science promotes expert-like thinking (Hammer, 1994; Otero and Gray, 2008) and reduces academic isolation, which promotes performance and persistence among URG students (Swarat et al., 2004). Mentors and teachers guide learners through active learning by teaching techniques to regulate physiological arousal, attention, and effort, while encouraging students to construct their own conceptual understanding of tasks and constructs (Bell, and Kozlowski, 2008). Even though active learning emphasizes the learners' role in knowledge acquisition, learners still need guidance from mentors to learn effective strategies while receiving feedback on their progress. Mentoring programs even present the capacity to close self-efficacy gaps between URG and non-URG college students (MacPhee, Farro, and Canetto, 2013).

Given the evidence for active learning as an effective mode of learning, research questions now center on the efficacy of different types of strategies (Bell and Kozlowski, 2008; Dou et al., 2018), who they benefit (Ballen et al., 2017), and the mechanisms that underlie them (Ballen et al., 2017; Cleveland et al., 2017). We contributed to this research by testing the role of active learning in promoting self-efficacy in STEM and in strengthening intentions to pursue STEM.

## Self-Efficacy

Performance in STEM gateway courses is repeatedly found to be a primary predictor of STEM persistence during college, and URG students typically underachieve in these notoriously rigorous courses relative to non-URG students (Chen and Soldner, 2013; Aulck et al., 2017), even after controlling for prior performance and preparation, suggesting that performance gaps are attributed to psychological processes instead of ability (Haak et al., 2011). One such psychological process linked to STEM performance is self-efficacy, which refers to an individual's belief in their capabilities in a certain domain, as well as being able to exercise control over their success in said domain (Bandura, 1977, 1982). Self-efficacy predicts future performance above and beyond past performance (Bandura and Locke, 2003). Among students who intend to major in STEM during college, those who leave STEM demonstrate lower self-efficacy than those who persist in STEM (Shaw and Barbuti, 2010).

Self-efficacy is a malleable source of domain-specific motivation and it covaries with appraisals of personal experiences, such as past performance, and situational factors, such as salient stereotypes (Fogliati, and Bussey, 2013; Schuck, 1989). Weak self-efficacy results in impaired academic performances (Pajares, 2005; Vogt, 2008), thereby creating a feedback loop such that personal interpretations of past performances alter self-beliefs and interactions with their environments, which then influence future performances (Pajares, 1996). As depicted in **Figure 1**, Bandura (1978) originally conceptualized this reinforcing cycle as *triadic reciprocality* in which environmental, behavioral, and personal factors continuously interact to either bolster or diminish performance. Active learning can increase self-efficacy via Bandura (1978) sources of self-efficacy–mastery experiences, psychological arousal, vicarious learning, and social persuasion. Mastery experiences such as hands-on guided exercises can increase self-efficacy over time, because the learner first decides how to approach the task, then continuously observes themself developing the skill, while simultaneously receiving positive feedback on their progress from teachers and mentors. For URG students pursuing STEM, mentorship enhances self-efficacy and intentions to persist because supportive mentors represent a powerful source of social persuasion by providing encouragement and recognition as a STEM group member (Betz and Schifano, 2000; Carlone and Johnson, 2007; Stout, Dasgupta, Hunsinger, and McManus, 2011). Mentors can also engage in intellectual discussions with the learners, which is a simple, yet effective active learning strategy that boosts self-efficacy and performance (Hammer, 1994; Otero and Gray, 2008).

Once a sufficient level of self-efficacy is achieved, it serves as a source of domain specific motivation where people put forth more mental effort (Rittmayer and Beier, 2008) and persist longer (Bandura, 1977). Low self-efficacy results in avoidance of tasks and relevant domains, whereas high self-efficacy promotes engagement, active participation, and sustained pursuit of challenging tasks (Pajares, 1996; Komarraju and Nadler, 2013). Self-efficacy is the mechanism underlying the relation between engaging in active learning strategies and superior performance among URG students in STEM (Ballen et al., 2017). Furthermore, the theorized link between self-efficacy and improved performance is due to increased self-regulation during performance such that one becomes more cognitively engaged, experiences lower physiological arousal, and involves continual self-evaluations during and after the task (Bandura, 1991; Zimmerman, 2000). Put another way, self-efficacious students are more likely to display the positive affect, attitudes, and self-directed behaviors needed for active learning (Pajares, 1996; Pajares and Schunk, 2001).

## Intentions to Pursue and Persist in STEM

STEM intentions reflect students' short- and long-term goals to pursue a STEM major, attend and complete graduate school in STEM, and establish a career in STEM, which are consistently associated with STEM persistence (Shaw and Barbuti, 2010; Maltese and Tai, 2011). Self-efficacy is intrinsically linked to career intentions, because students must first believe in their ability to produce a desired outcome in a given domain before they become motivated to pursue a career pathway (Bandura, 1991; Bandura, Barbaranelli, Caprara, and Pastorelli, 2001). Unsurprisingly, self-efficacy is a consistent predictor of STEM intentions among all students (Brown et al., 2016; Lent et al., 2016), and long-term engagement among URG students (Estrada, Woodcock, Hernandez, and Schultz, 2011). Some research even finds that STEM self-efficacy explains why participation in an academic support program is related to long-term intentions to pursue STEM careers (Syed et al., 2011). STEM self-efficacy appears to be a stronger predictor of career choice among URGs compared to non-URGs, at least among female students (Larose, Ratelle, Guay, Senécal, and Harvey, 2006).

## STEM Educational Interventions: High School and Community College

STEM interventions with URG students in secondary and higher education settings often focus on developing self-efficacy because of its relation to performance and persistence (Betz and Schifano, 2000; Rittmayer, and Beier, 2008; Ballen et al., 2017; Liu, 2018; Kuchynka, Gates, and Rivera, 2020). In high school, STEM participation is pivotal for long-term STEM engagement (Alkhasawneh and Hargraves, 2014; Chang, et al., 2014; Lee and Luykx, 2006; Mendez, Buskirk, Lohr, and Haag, 2008; Shaw, and Barbuti, 2010; Terenzini and Pascarella, 1980; Wang, 2013), but most students in the United States report a relative dislike and avoidance of STEM by high school (Chen and Soldner, 2013). Low STEM engagement during high school is believed to be caused by inadequate exposure to varied STEM materials (Kuchynka, Gates, and Rivera, 2020) and a lack of applied STEM courses that bridge abstract concepts to real-world applications (Bozick et al., 2014; Sublett, and Plasman, 2017). Furthermore, because they are more likely to attend high schools with inadequate resources (Duncombe and Cassidy, 2016) and encounter cultural stereotypes that undermine their STEM competence (Dasgupta, 2011), URG students are at an increased risk for avoiding versus approaching STEM during high school. Fortunately, active learning environments can counteract each of these barriers and in turn promote STEM self-efficacy and intentions to pursue STEM. Study 1 examines these hypotheses with URG high school students in a science education program.

Study 2 investigates these same hypotheses with URG community college students in a STEM mentoring program. More than half of URG students who received a STEM degree from a 4-year university transferred from community colleges (National Research Council and National Academy of Engineering, 2012). Consistent with the above literature review, self-efficacy is associated with future career decisions among community college students (Collins and Bissell, 2004; Amelink, Artis, and King Liu, 2015). Qualitative studies have identified socio-cultural issues (e.g., first generation status) and inadequate advising as two of the largest barriers to a successful transfer to a 4-year university (Gard, Paton, and Gosselin, 2012). Guidance from mentors, however, can improve community college students' self-efficacy over time, because mentors teach mentees strategies for a successful transfer (e.g., frequently asking clarification questions) and coping mechanisms, and they provide social support (Amelink, Artis, and King Liu, 2015).

# OVERVIEW OF THE PRESENT RESEARCH

Two longitudinal studies adopted active learning strategies to increase STEM engagement among URG students. The interventions targeted two different phases of students' educational development, high school students participating in a 4-week intensive geoscience summer program (Study 1) and community college students participating in a mentoring program (Study 2). Both studies investigate changes in STEM self-efficacy and future intentions to pursue STEM goals among URG students, and the reciprocal relation between these variables.

# STUDY 1

Study 1's longitudinal design tested if a 4-week geoscience summer program yields positive changes in STEM self-efficacy and intentions to pursue STEM with a sample of URG high school students. Past educational interventions that focus on developing self-efficacy include one or more of the following three components - social persuasion (positive and constructive feedback from important others), vicarious experience (learning STEM from observing peers or mentors), or mastery experience (hands-on exercises)—and all demonstrate varying degrees of success in cultivating self-efficacy (for a review, see Rittmayer and Beier, 2008). Study 1's geoscience program combines these intervention components, so we hypothesized that student participants will exhibit stronger STEM self-efficacy (Hypothesis 1) and its correlate stronger intentions to pursue STEM in the future (Hypothesis 2) from start to end of the program. Further, we explored whether the hypothesized changes in STEM self-efficacy explained increases in STEM intentions or vice versa. Finally, we explored if any observed changes in both criteria were qualified by perceptions of program quality. Previous research indicates that satisfaction with one's learning environment moderates psychological benefits and performance (Tinto, 1993; Allen and Robbins, 2008). A test of program quality also allowed us to demonstrate that any changes in STEM psychological outcomes as function of completing the program are not simply due to a longitudinal aging effect, which is when variables change as a result of a cohort aging as opposed to participation in the intervention itself (Blanchard, Bunker, and Wachs, 1977).

## Method

### Participants and Design

The study adopted a one-factor three-level (Time: 1/Day 1, 2/Day 9, 3/Day 19) within-participants repeated-measures design. We invited all high school students enrolled in a 4-week geoscience program at a northeastern university during the summers of 2018 ($n$ = 53) and 2019 ($n$ = 45) to participate in the study. Students participated in the program during each weekday for the duration of the 4-weeks from 8am to 2pm. Due to attrition, the total

**TABLE 1 |** Participants' Demographics.

| Variable | Study 1 | Study 2 |
|---|---|---|
| Age (mean years) | 15.27 (1.01) | 22.65 (5.16) |
| Gender | — | — |
| Male | 56.8 | 41.8 |
| Female | 43.2 | 58.2 |
| Ethnic-Racial Group | | |
| Black or African-American | 63.6 | 29.1 |
| Latinx or Hispanic | 21.6 | 43.6 |
| Middle Eastern or North African | 0.0 | 15.5 |
| White or European American | 0.0 | 2.7 |
| Asian or Asian American | 4.5 | 4.5 |
| American Indian or Alaska Native | 2.3 | 0.0 |
| Other Identity | 5.6 | 4.5 |
| High School/College Status | — | — |
| First year or Freshman | 22.7 | 18.2 |
| Second year or Sophomore | 37.5 | 70.9 |
| Third year or Junior | 27.3 | 8.2 |
| Fourth year or Senior | 10.2 | 1.8 |
| Parents Level of Education | | |
| GED | 4.5 | 2.7 |
| High School | 25.0 | 34.5 |
| Some College | 13.6 | 22.7 |
| College Graduate | 27.3 | 26.4 |
| Unknown | 26.1 | 13.7 |

Note. *Figures represent percentages, unless otherwise noted in parentheses after variable. For means, standard deviations are in parentheses.*

sample size of students who completed all measurements varied across the three time points (Times 1–3 *N*s = 97, 95, 88). According to G Power, a repeated measures MANCOVA with one group and three time-points yields a sample size of 86 to detect a small to medium effect size. Thus, our sample presents sufficient statistical power. **Table 1** lists all participants' demographics. Participation was voluntary, but students received a stipend for completing the program. We obtained both parental consent and child assent. This research was approved by the Rutgers University Institutional Review Board and was part of a larger preregistered study (see Open Science Foundation #32267; https://osf.io/a63m5/).

## Program and Procedure

The summer geoscience program was a 4-week intervention that educated high school students from a major urban city about earth resources, energy, and the environment (Gates, 2019). Student participants received mentorship from teachers and undergraduate college students and were immersed in a community of mostly Latinx and Black peers.[1] To the extent possible, the undergraduate student mentees were purposefully selected to match the demographics of the student participants (e.g., most were URG and from the same urban area) and were recruited from the Garden State Louis Stokes Alliance for Minority Participation (GSLSAMP; http://gslsamp.rutgers.edu/). The high school students actively participated in applied science exercises, such as taking water and soil samples, analyzing them with professional equipment in the laboratory, and observing geoscience in its natural environment during field trips. More specifically, active learning components included rock and mineral identification as applied to everyday and industrial use, seismic refraction profiling, radioactivity of rocks and radon in soil, assaying magnetite ore, gauging stations and flooding on a stream table, and geothermal energy. Instead of learning about abstract theoretical concepts, the geoscience program provided real-world applications for earth science material.

The measured variables listed below were completed online through Inquisit Web 5.0 (Millisecond software, 2018) in a computer classroom, three times across the 4-week program, unless otherwise noted in parentheses. Time 1 was the very first activity on day 1 of the program, Time 2 occurred around day 9, which was around the mid-point, and Time 3 was measured on day 19, the final day of the program. Participants completed the measures in the order listed below. Finally, at the end of Time 3, participants were provided with a full description of the study goals and the researchers' contact information.

## Measured Variables

### *STEM Self-Efficacy*

Adapted from Stout, Dasgupta, Hunsinger, and McManus (2011), participants responded to two items that assessed their appraisals of their talent and confidence in science—1) "Do you think you have a talent for science?" and 2) "How confident do you feel about your science ability?"—on 7-point scales ranging from 0 (not at all) to 6 (very much so). Higher scores indicate stronger STEM self-efficacy (Times 1–3 *r*s = 0.86, 0.78, 0.79).

### *STEM Intentions*

Adapted from research by Dasgupta and colleagues (Dasgupta, 2011; Stout et al., 2011), participants responded to two items that assessed their future intentions and aspirations in science—1) "If given the opportunity, how likely are you to pursue classes and courses in science in high school or college in the future?" and 2) "If given the opportunity, how likely are you to pursue a future job or career in science?" on 7-point scales ranging from 0 (not at all likely) to 6 (very likely). Higher scores indicate stronger future STEM intentions (Times 1–3 *r*s = 0.91, 0.92, 0.88).

### *Program Evaluation (Time 3 only)*

Three items evaluated participants' perceived quality of the program - 1) "Overall, how satisfied were you with the science summer program?," 2) "Overall, how would you rate the quality of the science summer program?," and 3) "Overall, how would you rate your learning in the science summer program?" on a 5-point scale ranging from 0 (very poor) to 4 (excellent), with 2 (average) as the midpoint. Higher scores indicate more favorable program evaluations ($\alpha = 0.86$).

### *Demographics*

Participants completed a demographics and background questionnaire at all three time points, which included gender,

[1]The third author (Gates) was one of the teachers, but he did not participate in the design and administration of, and was blind to students' performance on, the measured variables

**TABLE 2 |** Study 1: Zero-Order Correlations (N = 75).

| Variable | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| 1. GPA | 0.02 | 0.16 | -0.12 | 0.09 | 0.09 | 0.04 | 0.03 | 0.06 | 0.15 |
| 2. Program Quality | – | 0.09 | 0.03 | 0.04 | 0.18 | 0.41[a] | 0.21 | 0.28[b] | 0.26[b] |
| 3. HS Year | — | — | -0.01 | 0.05 | 0.05 | 0.01 | -0.04 | -0.02 | -0.05 |
| 4. SES | — | — | — | 0.05 | 0.03 | 0.01 | 0.01 | -0.02 | -0.14 |
| 5. Future Intentions - Time 1 | — | — | — | — | 0.81[a] | 0.57[a] | 0.62[a] | 0.54[a] | 0.44[a] |
| 6. Future Intentions - Time 2 | — | — | — | — | — | 0.63[a] | 0.48[a] | 0.52[a] | 0.46[a] |
| 7. Future Intentions - Time 3 | — | — | — | — | — | — | 0.39[a] | 0.49[a] | 0.53[a] |
| 8. Self-Efficacy - Time 1 | — | — | — | — | — | — | — | 0.66[a] | 0.55[a] |
| 9. Self-Efficacy - Time 2 | — | — | — | — | — | — | — | — | 0.71[a] |
| 10. Self-Efficacy - Time 3 | — | — | — | — | — | — | — | — | — |

[b]p < .05.
[a]p < .01.

**TABLE 3 |** Study 2: Zero-Order Correlations (N = 85).

| Variable | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 1. GPA | 0.04 | 0.18 | -0.04 | 0.20 | 0.41[a] |
| 2. SES | — | 0.04 | -0.09 | -0.02 | -0.03 |
| 3. Future Intentions Time 1 | — | — | 0.30[a] | 0.10 | 0.07 |
| 4. Future Intentions Time 2 | — | — | — | 0.27[b] | 0.17 |
| 5. Self-Efficacy Time 1 | — | — | — | — | 0.74[a] |
| 6. Self-Efficacy Time 2 | — | — | — | — | — |

[b]p < .05.
[a]p < .01.

grade point average (GPA), age, parents' education level, and ethnic-racial identification.

## Results

**Table 2** reports the descriptive statistics for all measured variables as a function of Time and the zero-order correlations among these variables. In the analyses below, we sought to understand the role of the intervention over time in STEM self-efficacy and future STEM intentions above and beyond any explained variance of year in high school and parents' level of education. More advanced students may start the program with stronger STEM self-efficacy and future STEM intentions due to their advanced experiences with high school science courses. Similarly, students from higher socio-economic status (SES) backgrounds may also start the program with stronger STEM self-efficacy and future intentions because of their access to greater academic and extracurricular resources in STEM.

### Effect of Time on STEM Self-Efficacy and STEM Intentions

To test our two main hypotheses, we ran a repeated measures MANCOVA in which Time was the within-subject three-level factor (Times 1–3), with the covariates discussed above included. **Table 4** lists means and standard errors of the outcome variables as a function of Time. The multivariate effect of Time was marginally significant [$F$ (4, 67) = 2.16, $p$ = 0.083, $\eta_p^2$ = 0.114]. Next, we ran pairwise comparisons to decompose the effect of Time on each of the two outcome variables.

First, STEM self-efficacy increased significantly from Time 1 to Time 3 [$M_{diff}$ = 0.37 $SE$ = 0.15, $p$ = 0.013, 95% CI (0.08, 0.66)], marginally increased from Time 2 to Time 3 [$M_{diff}$ = 0.21 $SE$ = 0.11, $p$ = 0.07, 95% CI (–0.02, 0.43)], and the change from Time 1 to Time 2 was not significant ($p$ > 0.20). Second, and similar to STEM self-efficacy, future STEM intentions increased significantly from Time 1 to Time 3 [$M_{diff}$ = 0.41 $SE$ = 0.18, $p$ = 0.021, 95% CI (0.07, 0.76)], marginally increased from Time 2 to Time 3 [$M_{diff}$ = 0.29, $SE$ = 0.17, $p$ = 0.089, 95% CI (–0.05, 0.63)], and the change from Time 1 to Time 2 was not significant ($p$ > 0.35). Thus, Hypotheses 1 and 2 were supported when we tested changes in the STEM psychological constructs from start to end of the program.

### Exploratory Tests

#### *Relation Between STEM Self-Efficacy and STEM Intentions*

Next, we explored if changes in STEM self-efficacy mediates changes in future STEM intentions or vice versa. To this end, we used Montoya and Hayes' (2017) MEMORE macro for repeated measures mediation, using Time as the predictor in both analyses. In the first analysis, STEM self-efficacy was the repeated measures mediator and future STEM intentions was the outcome variable, then this order was reversed in the second analysis.

Results showed that STEM self-efficacy indirectly predicted future STEM intentions, $b$ = 0.15, $SE$ = 0.10, 95% CI (0.01, 0.39). As per **Figure 2**, strengthening STEM self-efficacy from Time 1 to Time 3 appears to explain changes in student participants' intentions to pursue STEM in the future. Further, the direct effect of the duration of the intervention on future STEM intentions was not significant, $b$ = 0.21, $SE$ = 0.16, $p$ = 0.21, 95% CI [-0.12, 0.53], and the total effect reached significance, $b$ = 0.36, $SE$ = 0.17, $p$ = 0.039, 95% CI [0.02, 0.70]. Similarly, results also showed that future STEM intentions indirectly predicted STEM self-efficacy, $b$ = 0.11, $SE$ = 0.07, 95% CI (0.002, 0.28). As per **Figure 3**, strengthening future STEM intentions bolstered their STEM self-efficacy from Time 1 to Time 3. Further the direct effect of the duration of the intervention on STEM self-efficacy was non-significant, $b$ = 0.22, $SE$ = 0.13, $p$ = 0.09, 95% CI (–0.04, 0.48), and the total effect reached significance $b$ = 0.33, $SE$ = 0.14, $p$ = 0.017, 95% CI (0.06, 0.60).

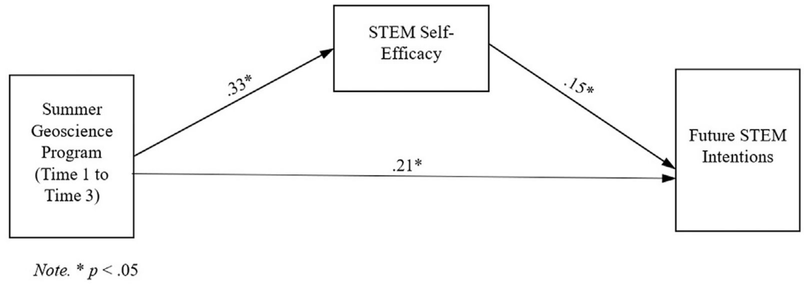


**FIGURE 2 |** Statistical model depicting effects of the summer geoscience program on future STEM intentions, mediated by STEM self-efficacy.

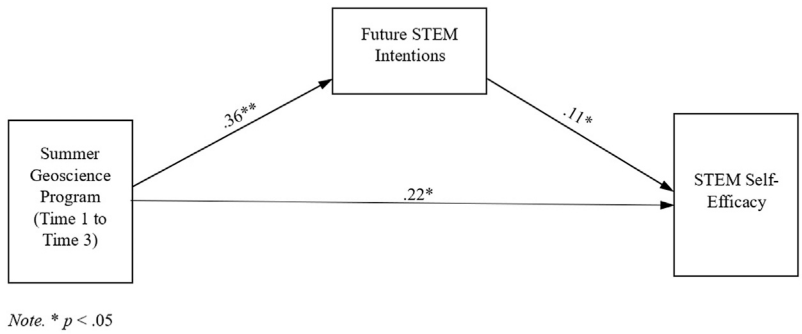


**FIGURE 3 |** Statistical model depicting effects of the summer geoscience program on STEM self-efficacy, mediated by future STEM intentions.

#### *Moderating Role of Program Evaluation in STEM Self-Efficacy and STEM Intentions Changes*

Finally, we submitted program evaluation as the moderator, and STEM self-efficacy and STEM intentions (Times 1 and 3) as the repeated measures outcome variables in two separate models, using Montoya and Hayes' (2017) MEMORE (macro Model 2). First, program evaluation significantly moderated changes in STEM self-efficacy from Time 1 to Time 3, $b$ = 0.91, $SE$ = 0.22, $p$ < 0.001, 95% CI (0.47, 1.35). STEM self-efficacy increased from start to end of program among participants who reported high program quality, $b$ = 1.01, $SE$ = 0.22, $p$ < 0.001, 95% CI (0.57, 1.45), but this was not the case among participants who reported low program quality, $b$ = 0.20, $SE$ = 0.19, $p$ = 0.29. Although the omnibus model did not exhibit a statistically significant interaction on STEM intentions, $b$ = 0.17, $SE$ = 0.19, $p$ = 0.35, 95% CI (−0.55, 0.20), the conditional effect was significant–STEM intentions strengthened from start to end of program among participants who reported high program quality, $b$ = 0.46, $SE$ = 0.19, $p$ < 0.05, 95% CI (0.07, 0.89), but this was not the case among participants who reported low program quality, $b$ = 0.29, $SE$ = 0.22, $p$ = 0.18.

## Discussion

Over the course of the 4-week science program, URG high school student participants' STEM self-efficacy and future STEM intentions increased from the program's start to its culmination. Furthermore, program evaluations moderated these effects–increases in STEM self-efficacy and STEM intentions emerged only among participants who reported high program quality. These findings suggest that only those who were satisfied with their participation in the active learning environment benefitted psychologically, which is consistent with past educational climate research (Tinto, 1993; Allen and Robbins, 2008). Finally, changes in self-efficacy mediated increases in future intentions to pursue STEM and vice versa. These findings shed light on the interconnected relation between STEM self-efficacy and the desire to pursue STEM goals - they seem to continuously reinforce each other over time.

# STUDY 2

Study 2 sought to examine the role of an isolated active learning component–mentoring–in URG community college students' STEM self-efficacy and future STEM intentions. Because mentors provide vicarious learning experiences and encouragement through verbal social persuasion, mentor-mentee relationships offer the potential to boost confidence in one's abilities, motivation, and academic goals. More than half of URG students who received a STEM degree from a 4-year university transfer from community colleges (National Science Foundation, 2012). Transferring from a community college to a 4-year university poses many obstacles, particularly ineffective advising and lack of information regarding the policies and

**TABLE 4** | Means and Standard Errors.

| Variable | Time 1 | Time 2 | Time 3 |
|---|---|---|---|
| Study 1 | — | — | — |
| STEM Self-Efficacy | 3.76 (0.16) | 3.93 (0.15) | 4.13 (0.14) |
| Future STEM Intentions | 3.73 (0.22) | 3.85 (0.21) | 4.15 (0.17) |
| Study 2 | — | — | — |
| STEM Self-Efficacy | 4.65 (0.11) | 4.71 (0.13) | — |
| Future STEM Intentions | 5.75 (0.06) | 5.75 (0.07) | — |

expectations of 4-year universities (Packard, Gagnon, LaBelle, Jeffers, and Lynn, 2011). Mentoring programs are one effective method for promoting transfer rates from community colleges to 4-year degree programs, because mentors ease anxiety and increase confidence (Townsend and Wilson, 2006). Study 2's semester-long mentoring program paired community college students interested in majoring in STEM (mentees) with undergraduate students majoring in STEM at a 4-year university.

# Method

## Participants and Design

The study adopted a one-factor two-level (Time: 1/beginning of program, 2/end of program) within-participants repeated-measures design. All URG students participating in the semester-long peer mentoring program in the spring 2019 ($N = 77$) and spring 2020 ($N = 59$) enrolled in the study. Due to attrition, the total final sample size of those who completed all measures at both time points was $N = 87$. Similar to Study 1, G Power indicates that a repeated measures MANCOVA with one group and two time-points yields a sample size of 92 to detect a small to medium effect size at 95% power. **Table 1** lists all participants' demographics. Participants received a small stipend for completing the mentoring program and participation in this study was a requirement of the mentoring program, but the informed consent notified them that their participation was voluntary and that they could withdraw at any time. We obtained informed consent from all participants. This research was approved by the Rutgers University Institutional Review Board and was part of a larger preregistered study (see As Predicted, https://aspredicted.org/q77vd.pdf, #38543).

## Program and Procedure

The mentorship program occurred over the course of one semester (Smart and Gates, 2018). Similar to Study 1, the mentors were recruited from GSLSAMP and selected to mirror the demographics of the mentees such that they were mostly Black and Latinx students pursuing 4-year STEM degrees who transferred from a community college. Mentees and mentors were expected to communicate for at least 30 min per week through emails, phone calls, video calls, or text messages. The mentors were trained prior to the program on how to be a role model, friend, guide, coach, and advocate for community college students. A program administrator (none of the authors served this role) provided initial guidance to address topics such as challenges and important lessons for college, mentoring and networking experiences, tips to prepare and apply to 4-year programs, and management of course schedule. Importantly, mentees were trained prior to the start of the intervention on how to actively communicate, problem solve, and set goals with their mentor. Mentees were instructed to take an active role in the relationship and to work jointly with mentors to address academic challenges.

Mentees completed the below measured variables online through Inquisit Web 5.0 (Millisecond software, 2018) at two time points, at the beginning and the end of the program. All students received an email from the research team that included information and instructions about the study. The email included a link to the study, a unique participant ID, and a date by which the study should be completed. The research team monitored the completion rate of the study and sent reminder emails when necessary. Participants were instructed to complete each time point in one session without interruptions. Participants first provided their online consent and then completed the measures of STEM self-efficacy and STEM intentions, and the demographics questionnaire, all in this order.

## Measured Variables

### *STEM Self-Efficacy*

We administered the same measure from Study 1, except that the items referred to "STEM" rather than "science" abilities and talents (Times 1–2 $r$s = 0.80, 0.88).

### *STEM Intentions*

Adapted from research by Dasgupta and colleagues (Stout et al., 2011; Dasgupta et al., 2015), participants responded to three items that assessed their intentions and aspirations to pursue STEM in the future—1) "At this time, how likely are you to transfer to a 4-years college or university in the future?" 2) "At this time, how likely are you to pursue a bachelor's degree in the future?" and 3) "At this time, how likely are you to pursue a STEM degree at a 4-years college or university in the future?"—on 7-point scales ranging from 0 (not at all likely) to 6 (very likely). Higher scores indicate stronger STEM intentions (Times 1-2 αs = 0.66, 83).

### *Demographics*

We administered the same measure from Study 1, in addition to items requesting information about participants' annual family income, employment, and marital status.

# Results

**Table 3** reports the descriptive statistics for all measured variables as a function of Time and the zero-order correlations among these variables. In the analyses below, we sought to understand the role of the intervention over time in STEM self-efficacy and future STEM intentions above and beyond any explained variance of students' SES. Students from higher SES backgrounds may start the program with stronger STEM self-efficacy and future intentions because of their access to greater academic and extracurricular resources.

## Changes in STEM Self-Efficacy and Future STEM Intentions

To test the same two main hypotheses in Study 1, we ran a repeated measures MANCOVA in which Time was the repeated measures two-level factor (Times 1–2), with the covariates discussed above included. **Table 4** lists means and standard errors of the outcome variables as a function of Time. The multivariate effect of Time was not significant ($F(2, 81) = 0.22$, $p = 0.803$, $\eta_p^2 = 0.005$)—that is, student participants' STEM self-efficacy and future intentions to pursue STEM remained stable over time.

## Discussion

In retrospect, Study 2's data are consistent with past STEM intervention research indicating that URG students do not consistently show changes in cognitive, motivational, and attitudinal changes throughout college (Dennehy and Dasgupta, 2017; Estrada et al., 2019). First, students who enter college in pursuit of STEM typically demonstrate high STEM self-efficacy, but often experience a decrease in self-efficacy when they are exposed to the rigors of STEM coursework and expectations (Liu, 2018; Kuchynka et al., 2019). It appears that self-efficacy drops are explained in part by the anxiety and self-doubt experienced during the transition from high school to college (Rosenthal et al., 2011), and the stress experienced when transferring from a 2-years to 4-years institutions (Laanan, 2001). Moreover, URG students may be at an increased risk of fluctuating self-efficacy during college, because they are more likely to experience academic isolation (Malone and Barbino, 2009; Grossman and Porche, 2014), bias (Swim, Hyers, Cohen, Fitzgerald, and Bylsma, 2003; Rankin and Reason, 2005), and a lack of support and recognition (Carlone, and Johnson, 2007).

It should be noted, however, that the community college student participants reported relatively strong STEM self-efficacy and future intentions to pursue STEM at the beginning of the program, and that the strength of these psychological constructs were maintained through the end of the program (from **Table 4**, means were 4.65 and 4.71, and 5.75 and 5.75, both on 0 to 6 scales, respectively). The future STEM intention scores indicate that the students who joined the program already intended to transfer to a 4-year university. Thus, these participants represent students committed to STEM goals as measured by their strong STEM intentions from the start to completion of the program even though these students are going through a potentially stressful transition period. Mentorship during this time may have helped to buffer URG students' STEM self-efficacy and intentions to pursue STEM in the future.

# GENERAL DISCUSSION

Two longitudinal studies with URG students examined the role of two STEM interventions with active learning components in increasing STEM self-efficacy and intentions to pursue STEM in the future. In Study 1, high school URG students exhibited stronger STEM self-efficacy and stronger future STEM intentions over a 4-week geoscience program, and these two constructs were mutually related. In Study 2, community college URG students showed stable STEM self-efficacy and future STEM intentions across a semester-long mentorship program.

## High School

High school represents the first time most students are exposed to advanced STEM content and given the opportunity to select or "opt-out" of a STEM pathway by avoiding advanced STEM classes. To facilitate a positive STEM self-concept and approach orientation toward STEM, high school students need low-stakes STEM exposure, where they can actively explore the material under the guidance of peers, mentors, and teachers without the pressure of testing, picking a major or a career (Kuchynka, Gates, and Rivera, 2020). Accordingly, Study 1 immersed high school URG students in a collaborative community of like-minded peers as well as mentors and teachers, who guided them through various active learning exercises including hands-on applications, group projects, and field trips. This out-of-school intervention provided students with opportunities to repeatedly experience three sources of self-efficacy - task mastery, vicarious learning experiences, social persuasion - in an inclusive environment for 4 weeks under the guidance of mentors and teachers. Students witnessed their peers and undergraduate student mentors engage with hands-on material (vicarious learning experiences), and received immediate feedback including encouragement and validation (social persuasion) as they worked independently and collaboratively on STEM tasks (task mastery) in a low stress environment without the pressures of testing. In sum, this engaging and inclusive environment played a positive role in STEM self-efficacy and intentions to pursue STEM in the future STEM.

Consistent with past research, the mutual relation between self-efficacy and future intentions observed in Study 1 suggests that these constructs are self-reinforcing (Nauta, Epperson, and Kahn, 1998; Nauta, Kahn, Angell, and Cantarelli, 2002; Zeldin, Britner, and Pajares, 2008; Byars-Winston et al., 2010). Before someone commits to pursuing a career goal, they must first believe in their ability to achieve success (Bandura, 1991; Bandura, Barbaranelli, Caprara, and Pastorelli, 2001), which, in turn, motivates them to pursue and achieve short-term and long-term goals related to that career (Pajares, 1996). Our data suggest that the development of future career intentions and self-efficacy are intertwined and continuously reinforce each other across time, enhancing approach motivation toward relevant tasks. Highly self-efficacious STEM students might be more likely to actively seek support from teachers or professors by attending office hours, as well as seeking out research opportunities in which they also collaborate with more advanced STEM students (Pajares, 1996; Pajares and Schunk, 2001). Moreover, they might join clubs or study groups that provide opportunities for extending their network of STEM peers, trainees, and researchers. Under the wrong conditions, students can be caught in a negatively reinforcing cycle, such that encountering one or more negative experiences with STEM promote early feelings of avoidance and self-doubt that reduce the likelihood of reengaging with STEM material. However, providing high school students with positive and satisfying educational climates to learn STEM material can foster an early approach orientation that promotes reengagement with STEM material over time.

Notably, only high school student participants who reported high program quality yielded the expected psychological gains, highlighting the importance of being satisfied with one's academic environment. It appears that greater exposure to STEM material does not automatically result in enhanced self-efficacy over time if the learning environment does not fulfill students' perceived needs for competence, autonomy, and belonging (Liu et al., 2014). This is doubly important for URG students because they are more likely to attend schools with inadequate resources (Duncombe and Cassidy, 2016), encounter cultural stereotypes that diminish STEM competence (Dasgupta, 2011), and be exposed to STEM educational climates harmful to the development of self-efficacy (Betz and Schifano, 2000).

## Community College

Study 2 found that self-efficacy and STEM intentions remained stable across the semester-long mentoring program. The brevity of 2-year degree programs at community colleges presents a unique life transition, such that (traditional) students are simultaneously learning new norms and expectations, while preparing to transition to a 4-year university with its own set of norms and expectations (Terenzini, et al., 1994). Most students participating in Study 2 recently transitioned to community college from high school, and they are already planning their transition to a 4-year institution. Transitioning from high school to community college and community college to a 4-year institution is characterized by stress and self-doubt about "fitting in" and whether one will be successful, especially among first-generation college students (Terenzini, et al., 1994). Guidance from mentors can ease transitions, because they are trustworthy confidants and they teach mentees how to handle unforeseen challenges while providing emotional support and validation. Mentorship can maintain students' confidence in their abilities and goals during stressful transition periods.

Study 2's community college students were trained at the start of the program to take an active role in the mentee-mentor relationship. Mentees were taught what questions to ask, how to communicate with their mentor, and how to work jointly to solve their academic problems. In other words, the mentees were taught active learning strategies at the start of the intervention to maximize its benefits. Past research has demonstrated that mentorship improves community college students' self-efficacy over time because mentors teach mentees strategies to regulate physiological arousal, provide a social support system, and offer positive validation (social persuasion) of skills and future success (Amelink, Artis, and King Liu, 2015; Terenzini, et al., 1994). Mentors also serve as a role model for mentees to emulate behaviors and align goals (Morgenroth, Ryan, and Peters, 2015). More specifically, mentees observe (vicarious experiences) mentors pursue a 4-year STEM degree, which teaches the mentees about the norms and expectations of 4-year STEM programs. Lastly, because mentors are typically selected to mirror the demographics of the mentees, mentors represent an inclusive exemplar, which counters cultural notions about who belongs and succeeds in STEM (Dasgupta, 2011; Dennehy and Dasgupta, 2017).

Instead of exclusively focusing on how to increase self-efficacy and future intentions, researchers should also address research questions about how to protect these psychological constructs during critical periods of development. Past research highlights the instability of self-efficacy during transition periods and college (Estrada et al., 2019; Kuchynka et al., 2019; Liu, 2018; Rosenthal et al., 2011). The community college students participating in Study 2's mentorship program sought to transfer to a 4-year university, and started the intervention with relatively strong intentions to pursue STEM and high self-efficacy levels. Even though these students had set goals and felt confident about their STEM abilities, they needed continued guidance and validation from mentors to persist in reaching their academic and career goals.

## Implications

Together with research showing that self-efficacy is linked to STEM persistence and performance across all educational phases (Collins and Bissell, 2004; Estrada, Woodcock, Hernandez, and Schultz, 2011; Amelink, Artis, and King Liu, 2015; Lent et al., 2016), our data have implications for closing performance and persistence gaps between URG and non-URG students. Ethnic-racial group differences in STEM participation are observed starting in high school with URG students taking less advanced STEM courses (Tyson, Lee, and Borman, 2007). Low STEM engagement during high school can be effectively ameliorated by immersing students in inclusive and collaborative communities, while providing students with repeated opportunities to learn varied STEM content that applies STEM concepts to real-world applications (Bozick et al., 2014; Plasman et al., 2017; Sublett, and Plasman, 2017). Active learning environments that encourage students to construct their own understanding of STEM material via hands-on exercises under the guidance of mentors and teachers promote self-efficacy and the pursuit of STEM goals. The relative brevity of Study 1's summer science program (4 weeks) demonstrates the ease of developing self-efficacy among URG high school students if placed in the right educational climate.

## Limitations

Study 1 and Study 2 did not include comparison groups, so we cannot account for possible self-selection (i.e., students who decided to participate in these programs may be more self-motivated than the average high school or community college students) or longitudinal time effects (i.e., the sheer passage of time can influence participants' psychological constructs). To address this limitation, Study 1 tested if program quality moderated increases in STEM self-efficacy and future intentions; because program quality was a significant moderator, increases in self-efficacy and STEM intentions can be attributed to participation in the STEM program. Study 2 did not include a parallel measure of program quality, so we were unable to consider longitudinal time effects. Future studies should experimentally control for the possibility of selection effects by randomly assigning URG students to either a STEM intervention or a control group. Another future direction is to isolate specific aspects of active-learning programs that yield the most benefits for students.

## Conclusion

Research spanning the past 3 decades repeatedly identify the following barriers for URG students in STEM: academic isolation (Malone and Barbino, 2009; Grossman and Porche, 2014), bias (Swim, Hyers, Cohen, Fitzgerald, and Bylsma, 2003; Rankin and Reason, 2005; Brown et al., 2016; Kuchynka et al., 2018), lack of mentorship (Pfund, Byars-Winston et al., 2015), lack of role models (Dasgupta, 2011, 2014), and a general lack of support (Swarat et al., 2004). All of these findings coalesce to suggest that URG students need immersion in welcoming educational environments that fulfill their needs for belongingness and validate their abilities and goals. Active learning environments work to satisfy belongingness, autonomy, and competence needs, which are all required for adaptive and healthy academic motivation (Gagné and Deci, 2005). Consistent with this, our research demonstrates that STEM self-efficacy and the pursuit of future STEM goals are dependent on providing a supportive and inclusive educational environment.

## DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: SK and LR (2021, January 26). Geoscience Summer Intervention. Retrieved from osf. io/a63m5.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board, Rutgers University, Newark. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## AUTHOR CONTRIBUTIONS

SK wrote the manuscript and analyzed the data with the support of LR. LR conceptualized the studies with the help of SK and TR. TR helped with programming the studies, collecting the data, and preliminary analyses, with the support of LR. AG and LR are the principal and co-principal investigators, respectively, on the NSF GSLSAMP grant.

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# Supporting Historically Underrepresented Groups in STEM Higher Education: The Promise of Structured Mentoring Networks

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Although institutions of higher education have placed a large emphasis on increasing the number of underrepresented minority (URM) students matriculating in higher education, the disparities in STEM retention and graduation rates between URM and non-URM students emphasize the dire need for increased support to help URM students navigate challenges including stereotype threat, impostor phenomenon, and lack of social connectedness that disproportionately affect URM students in majority-dominated fields. Prior research has demonstrated that structured mentoring has the potential to generate substantial improvements in academic, social, and career outcomes for URM STEM students. In particular, network-based mentoring approaches that allow for students to receive both professional and peer mentoring, as well as the opportunity to mentor other students, have demonstrated success in this realm. In this article, we discuss how the current state of academia often fails URM STEM students and faculty, review literature regarding the ways in which structured mentoring approaches can alleviate barriers to success among URM groups in STEM fields, and offer recommendations regarding how academic institutions can successfully implement holistic student and faculty mentoring programs.

**Keywords: mentoring, diversity and inclusion, STEM—science technology engineering mathematics, minority, broadening participation, higher education, networks**

## THE IMPORTANCE OF ACCESS TO MENTORS AND ROLE MODELS

Given the large-scale challenges currently facing our society, it is undeniable that STEM education is imperative for solving problems such as sustainable energy, national security, and effective prevention and response to widespread disease, such as the current coronavirus pandemic. Yet, it is also indisputable that there is a glaring chasm within the U.S. STEM workforce. Although individuals who identify as African-American/Black, American Indian or Alaska Native, or Hispanic/Latino make up 33.2% of the U.S. population (U.S. Census Bureau, 2019), only 22% of STEM undergraduate degrees and 9% of doctoral U.S. STEM degrees in 2016 were awarded to students identifying with one or more of these groups (NSF NCSES, 2019). Further, the current 6-year graduation rate for underrepresented minority[1] (URM) STEM majors is 33.8% as compared to 53.1% for White STEM majors (Whalen and Castleberry, 2019). Although predominantly White institutions (PWIs) have placed a large emphasis on increasing the number of URM students matriculating in higher education (Reardon et al., 2018), these institutions generally have not placed a comparable emphasis on providing support to URM STEM students to help them navigate the added challenges they face as URM students in majority-dominated fields (Hurtado et al., 2015; Sowell et al., 2015). As a result, a large body of evidence indicates that URM individuals in STEM fields report feeling invisible, isolated, and undervalued, not only as students but throughout their entire careers[2] (Walton and Cohen, 2007; Malone and Barabino, 2009; Schwarz and Hill, 2010).

Even more concerning is the underrepresentation of minority groups in STEM academic professions, as only 8.9% of STEM academic faculty are members of URM groups (NSF NCSES, 2019). Further, URM individuals make up only 3.9% of biology and chemistry faculty at the top 40 universities in the United States (Li and Koedel, 2017). This underrepresentation in academia often means that compared with White peers, URM STEM students and faculty do not have comparable access to similar-background role models, mentors, and informal networks that are critical to academic success and career advancement (Smith et al., 2000; Chen and Li, 2009; Byars-Winston and Dahlberg, 2019; Harris and Lee, 2019). Specifically, lack of access to role models can result in reduced satisfaction, self-efficacy, engagement, and achievement (Thomas, 2001; Schulze, 2010). In one study of career trajectories of minority and white professionals, Thomas (1990, 2001) concluded that minorities who advanced furthest in their careers all shared one common characteristic: A strong network of mentors who nurtured their professional development. Regarding STEM professions, this disparity in available mentors can influence URM students and faculty to leave STEM fields, resulting in a missed opportunity for highly talented individuals to contribute to the STEM workforce. In fact, URM chemistry students studying in departments that include at least one underrepresented faculty member are more likely to aspire to faculty positions in research-intensive institutions than those in departments without any URM faculty members (Stockard et al., 2021). Although one could make the case that mentors can be and have been effective even with mentees whose racial backgrounds differs from their own, the amount of time, effort, dedication, knowledge, and skill it takes to be effective mentors with mentees who are already isolated in a predominantly white institution is quite high (Thomas, 1993). Thus, many mentors may not have the requisite training to provide URM mentees with the kind of mentorship needed to navigate racial barriers and thrive in an isolating academic environment (Stanley and Lincoln, 2005). In fact, a study of 603 STEM doctoral programs across the United States found that only 36% offer targeted mentoring or peer mentoring for URM doctoral students and only 26% offer mentor training for faculty (Sowell et al., 2015), indicating that the current state of support for URM STEM doctoral students is sorely lacking in most academic institutions.

We postulate that the lack of diversity and representation within academic STEM departments creates a perpetuating cycle wherein the dearth of URM STEM faculty leads to fewer URM STEM graduates, resulting in fewer URM individuals entering faculty positions. However, even among URM students who do graduate with a STEM degree, a considerably smaller percentage go on to obtain academic faculty positions compared with their White peers (NSF NCSES, 2019). Therefore, in addition to increasing representation of URM students in STEM, we argue that STEM academic departments must undertake greater efforts to encourage URM students to explore academic careers. Furthermore, STEM colleges and departments must not only *hire* URM faculty but *invest* in these faculty by cultivating an environment of inclusion that fosters a sense of belonging among minority faculty. As Manuel and Karloff (2020) note, instead of asking whether a faculty *candidate* has what it takes to succeed, academic institutions should ask whether the *institutional environment* has what it takes to support a candidate's success.

In this vein, many of the mentoring tenets for students can also be applied to cross-race mentoring of faculty members. One way that academic departments can create this kind of inclusive environment is to organize faculty mentoring programs that allow established faculty members to provide listening, support, and guidance to newer faculty members, especially URM faculty who may feel unsupported, misunderstood, or unable to connect with others in the department (Stanley and Lincoln, 2005). However, mentoring faculty members requires training in how to establish a trusting, supportive relationship, and an understanding of how systemic inequality in the academic environment creates barriers for URM groups, making it critical for departments to arrange for faculty mentors to receive this kind of professional learning prior to working with their faculty mentees.

As outlined in this manuscript, structured mentoring programs for URM STEM students and faculty provide a promising approach to addressing race barriers because they can provide appropriate training prior to establishing the mentor–mentee relationship, thus benefitting mentees both within and outside of the program. In the following sections, we explore literature documenting major barriers to retention and graduation of URM STEM students, provide evidence for the benefits of structured mentoring programs, and describe a model for implementing successful mentoring programs using an inter-institutional approach.

[1] We use the term "underrepresented minority" (URM) to refer to individuals who identify with one or more groups whose representation in STEM education and employment is smaller than their representation in the U.S. population. These groups include: Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives (NSF INCLUDES Alliance, 2020).

[2] Although we acknowledge that there are other groups including women and first-generation students that face systemic barriers in STEM fields and strongly support efforts to increase equity for these groups, our work and expertise is primarily focused on URM groups, and this article is directed toward increasing success for these individuals.

## MENTORING FOR REDUCING RETENTION AND GRADUATION BARRIERS AMONG UNDERREPRESENTED MINORITY STEM SCHOLARS

Although there are numerous factors that influence URM student retention, graduation, and career choices, we focus on four of the most challenging barriers faced by URM groups in higher education: stereotype threat, microaggressions, impostor phenomenon, and lack of social connectedness. In this section, we highlight how these issues may prevent both URM students and faculty from reaching their full potential and describe evidence regarding the potential for mentoring to prevent or reduce the negative impacts of these barriers.

### Stereotype Threat

A well-established phenomenon, stereotype threat refers to the negative effects of identity stereotypes on the performance of members of groups when engaged in activities related to those stereotypes (Steele and Aronson, 1995). Stereotype threat has been shown to negatively impact the performance and retention of URM groups (Walton and Cohen, 2003; Spencer et al., 2016; Thomas and Erdei, 2018), especially in STEM fields (Beasley and Fischer, 2012; Woodcock et al., 2012, 2016). In a longitudinal study using a large, nationally representative sample of undergraduate minority science students, Woodcock et al. (2012) found that stereotype threat was associated with scientific disidentification, predicting a decline in students' persistence toward STEM careers. Stereotype threat is not only prevalent in URM STEM students, however, but also among URM STEM faculty. Studies indicate that the effects of stereotype threat for marginalized groups at the faculty level are much like those effects noted at the student level and include reduced openness to feedback, reduced domain identification, reduced engagement, and career aspirations (Casad and Bryant, 2016). These effects, if not addressed, can lead to faculty reluctance in pursuing leadership roles that make them accessible to students that need support and advocacy.

Several studies have attempted to reduce stereotype threat by conducting values affirmation exercises, but have produced mixed results, with several findings failing to be replicated in the same setting (Kost-Smith et al., 2012; Harackiewicz et al., 2014, 2016; Borman et al., 2016; Hanselman et al., 2017). A potential reason for lack of consistent findings of these studies is that engaging URM groups in periodic values exercises merely treats "symptoms" of a larger systemic issue rather than making long-term transformations in academic and social systems that contribute to this issue. Culturally responsive mentoring programs represent a promising approach for combating the effects of stereotype threat, as they offer a consistent and institutionalized method for ensuring that URM students and faculty receive value and identity affirmation (Mondisa and McComb, 2015; San Miguel and Kim, 2015; Byars-Winston and Dahlberg, 2019). Indeed, recent work suggests that a major factor responsible for preventing and reducing the effects of stereotype threat is interactions that URM groups have with "like me" faculty and mentors (Thomas and Erdei, 2018). Further, a study of undergraduate URM STEM students revealed that those who had received culturally responsive mentoring reported feeling greater confidence as researchers and became more committed to pursuing graduate degrees (Haeger and Fresquez, 2016). Additional support for the importance of role models comes from Meador (2018), who used a qualitative case study approach to examine factors that influenced recruitment and retention among undergraduate minority STEM majors. Students frequently cited role models, including teachers and family members, as the primary inspiration for their choice to pursue a STEM degree and a major reason for choosing to remain in their major even when it became challenging. These studies suggest that culturally responsive mentoring can provide protective effects against the negative impacts of stereotype threat. Although research investigating methods for combating stereotype threat for URM STEM faculty in particular is scarce, studies suggest that having a network of like-minded peers, mentors, and advocates in work settings is an effective strategy that can mitigate stereotype threat (Block et al., 2011).

### Microaggressions

A related barrier for URM groups in STEM fields is the occurrence of microaggressions, which refer to "subtle insults (verbal, non-verbal, and/or visual) directed toward people of color, often automatically or unconsciously" (Solorzano et al., 2000) and can trigger experiences of stereotype threat (Bair and Steele, 2010; Harrison and Tanner, 2018). Microaggressions are commonly experienced by URM groups in many social settings (Sue et al., 2007), and there is a wealth of literature focusing on microaggressions in higher education environments (Young et al., 2015; Harris et al., 2019; Lee and Hopson, 2019; Ogunyemi et al., 2020). Examples of microaggressions include playing down the importance of certain individuals' viewpoints or racial identities, expressing an assumption that insinuates a stereotype, asserting that others "shouldn't be so sensitive," or pathologizing cultural differences, including communication styles (Sue et al., 2007; Sue, 2010). Evidence indicates that microaggressions can have negative psychological effects that detract from wellbeing, and interfere with learning, engagement, and social connectedness in academic settings (Torres et al., 2010; Wang et al., 2011). Recipients of microaggressions may face difficulties interpreting whether their assumptions about the intent of such acts are valid, and whether it's worth the effort to say something or let it go. Such dilemmas may be especially challenging if the act is committed by an authority figure within the academic environment (e.g., professor/advisor for students or chair/dean for faculty members) (Harris and Lee, 2019).

At the faculty level, URM groups report experiencing microaggressions in much the same way as URM students. It is not uncommon for URM faculty to encounter colleagues who assume they are incapable of successfully navigating the rigors of academic positions, and begin to sow seeds of doubt in their counterparts (Solorzano, 1998; Sue et al., 2007; O'Meara et al., 2019). The subtle forms of discrimination that shape professional interactions among URM faculty and colleagues can have serious consequences, as studies demonstrate that small forms of discrimination over time can result in severe problems for faculty including health problems, dissatisfaction, and departure from their position (Griffin et al., 2011; Thomas et al., 2014).

Although persistent microaggressions can leave URM students and faculty feeling as though they don't have what it takes to succeed in Alexander and Hermann (2016), mentoring that explicitly addresses these issues has the potential to combat their negative impacts (Harris and Lee, 2019). As noted by Harris and Lee (2019), mentoring can help mitigate the effects of microaggressions if (1) mentors and mentees have open dialogue and acknowledge that the mentee experiences racial barriers, (2) the pair discuss the mentee's needs related to race-based challenges, and (3) mentors share their plans and progress regarding their efforts to address social injustices currently affecting the mentee. Such communication places both mentor and mentee on the same page and allows them to better understand the goals of the mentee. In addition, mentors can utilize positive micromessaging to affirm their mentees' competence and foster a growth mindset (Lee, 2018; Kyte et al., 2020). Given the necessity of effective communication in mentoring relationships, it is critical for mentors to receive proper training in fostering open dialogue, especially concerning issues of race and racial justice.

## Impostor Phenomenon

Another barrier commonly experienced by URM students and faculty in academic settings, impostor phenomenon refers to a feeling that one is not truly as capable or intelligent as others perceive them to be, which results in the self-perception that one is a fraud (Clance and Imes, 1978). Along with this feeling of fraudulence, individuals experiencing impostor syndrome often have a pervasive fear of being found out or exposed by others, making it difficult for them to be confident that their successes are due to their ability, hard work, and intelligence (Harvey and Katz, 1985; Chakraverty, 2019; Feenstra et al., 2020). URM students who enter into STEM programs may experience impostor phenomenon, which can lead to mental health concerns such as depression (McGregor et al., 2008), anxiety (Thompson et al., 1998, 2000; Fraenza, 2016), lowered self-esteem (Sonnak and Towell, 2001), low self-efficacy (Blondeau and Awad, 2018), procrastination, perfectionism, self-doubt (Fraenza, 2016), and self-handicapping (Ferrari and Thompson, 2006). Similarly, URM academics who experience imposter phenomenon describe this encounter as persistent thoughts of intellectual deception (Hutchins and Rainbolt, 2017). Results of this prolonged experience causes severe psychological stress that results in faculty from URM groups questioning their acceptability and aptitude in academic environments (Hall and Burns, 2009; Dancy and Jean-Marie, 2014).

Despite much of the research on impostor phenomenon focusing on the personal characteristics of the individuals who develop it, studies indicate that relationships with others in the academic environment also play a significant role in determining the prevalence of this phenomenon (Barnes and Austin, 2009; Baker et al., 2014; Feenstra et al., 2020). Thus, to reduce impostor phenomenon, mentoring programs must focus not only on the characteristics of individuals or the environment in isolation in isolation but also on the fit between mentors and mentees. Indeed, there is evidence suggesting that proper mentor–mentee fit can reduce impostor phenomenon (Sanford et al., 2015; Cohen and McConnell, 2019; Barr-Walker et al., 2020; Chakraverty, 2020). Specifically, Baker et al. (2014) stress the importance of basing mentor–mentee fit on three aspects of identity: (1) professional identity (perceptions of self-related to the major tasks and roles of the academic career); (2) relational identity (self-concept as it relates to family roles and responsibilities and interpersonal relationships outside of the professional context); and (3) personal identity (general sense of self, including the perceived salience of personal characteristics within specific contexts). Thus, to reduce impostor phenomenon, STEM academic departments should consider administering surveys to students and faculty and utilizing the results to match mentors with mentees according to these three types of identity.

## Sense of Belonging and Social Connection

A fourth major barrier that can reduce URM students' interest in STEM and lead to dropout is low levels of social connectedness and what researchers have called "belongingness": the perception of acceptance, connection, and social support one receives as well as feelings of mattering and being valued and respected by the community (Baumeister and Leary, 1995; Stachl and Baranger, 2020). A strong connection to one's environment, via positive and frequent interactions with diverse peers, is associated with greater persistence and academic achievement (Walton and Cohen, 2007; Zaniewski and Reinholz, 2016; Ito and McPherson, 2018) and having a sense of belonging is a known indicator for STEM retention (Kim and Sinatra, 2018; Robnett et al., 2018). Research indicates that URM students, particularly at PWIs, experience challenges connecting socially and culturally with the overall campus community, and report greater feelings of isolation than White students (Strayhorn, 2009). URM students describe several factors responsible for feelings of isolation and social separation including a negative campus climate, racist and/or sexist interactions with White peers and faculty members, and having a strong racial identity that is marginalized at their institution (Brown, 1990; Locks et al., 2008; Thelamour et al., 2019). For URM faculty, isolation is often both institutional (i.e., feeling that they lack knowledge about and access to sources of power, prestige, support, and information that is important for career success and social (feeling excluded from supportive networks and limited to superficial friendships because others are unable to relate) (Smith, 1998; Smith and Markham, 1998; Smith and Calasanti, 2005). Given that feelings of isolation are a central factor impeding both URM student and faculty success in STEM (Fisher et al., 2019), institutions of higher education and individual STEM colleges, schools, and departments must work to foster a culturally inclusive environment that promotes a sense of belonging so as to increase STEM retention and success (Johnson and Elliott, 2020).

Several studies have demonstrated positive impacts of mentoring relationships on mentees' sense of belonging (Chan, 2008; Stolle-McAllister et al., 2011; Apriceno et al., 2020). Apriceno et al. (2020) found that both URM and non-URM STEM students who reported having an engaged mentor early during their first year of college reported significantly greater academic self-efficacy and sense of belonging than those without mentors. With regard to specific populations, research suggests that greater levels of support from mentors is associated with a stronger sense of belonging among Black (Maton et al., 2000), Hispanic (Holloway-Friesen, 2019), and international students (Curtin et al., 2013). The impact of mentoring on students' sense of belonging also applies to mentoring received from peers (Maton et al., 2000; Inzlicht et al., 2006) as connecting with similar-age students who have similar backgrounds and interests can normalize struggles and bolster students' positive science identities (Zaniewski and Reinholz, 2016). This finding suggests that peer mentoring may be a powerful addition to faculty mentoring in alleviating barriers and supporting the success of URM students (Craig, 2019). Although research regarding the role of mentoring in increasing faculty members' sense of belonging is scarce, Wright-Mair (2020) indicates that mentoring relationships, including holistic and critically conscious mentoring by colleagues, supportive peer mentoring, mentoring students, and community-based mentoring relationships have the potential to enhance feelings of social connection for URM faculty at PWIs. Taken together, the extant literature strongly points to the role that supportive mentoring relationships play in facilitating career success for URM groups.

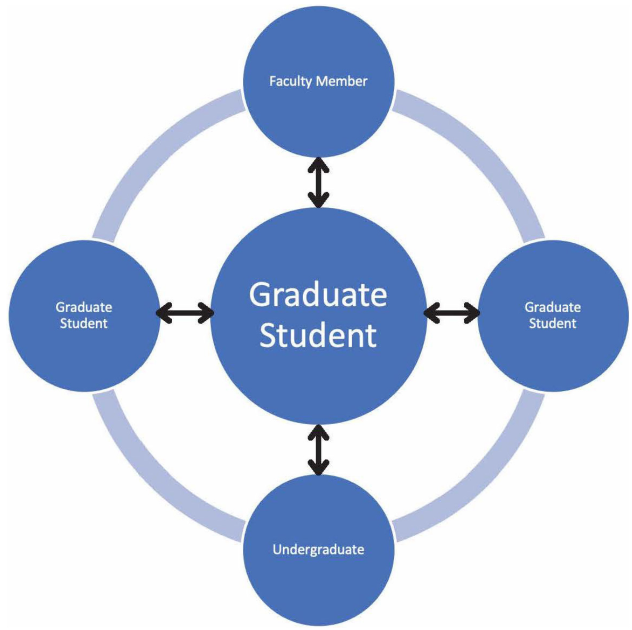


**FIGURE 1 |** Depiction of non-dyadic, holistic mentoring relationships utilizing an example of a graduate student who receives mentorship from a faculty member while providing mentoring to undergraduates and peer mentoring to fellow graduate students.

## MENTORING UNDERREPRESENTED MINORITY STUDENTS IN HIGHER EDUCATION: A ROADMAP FOR DIVERSIFYING THE STEM WORKFORCE

Thus far, we have discussed the potential for mentoring to mitigate challenges faced by URM groups in academia. However, mentoring that effectively maximizes academic and career success among URM STEM students requires innovative structures, a comprehensive implementation plan, buy-in and commitment from both administrators and faculty, and coordination among key stakeholders within and outside the academic environment. In this section, we offer recommendations that institutions of higher education can take to implement a system of mentoring that meets the needs of URM groups.

### Recommendation 1: Create Opportunities for Non-dyadic Mentoring

The prevailing model utilized in academic environments involves dyadic mentoring, in which one mentee works with one mentor to acquire knowledge and skills in a specific research area. Some mentors may also provide personal and career advice, but this is typically not required and is left up to the mentor to decide if they want to offer this type of guidance. While URM students and faculty can certainly benefit from structured dyadic mentorships, these relationships are often limited because a single mentor may not have the capacity, breadth of knowledge, or expertise to adequately address all of a single mentee's needs (Yun et al., 2016). In terms of social capital, there are many beneficial networks that are not being leveraged in the traditional dyadic model. As the National Academies of Sciences, Engineering, and Medicine (2019) suggest, there are often more effective approaches for mentoring than a singular relationship between one mentee and one mentor, especially in contexts with relatively few available mentors or in which mentees have varied needs. Therefore, dyadic relationships are important, yet insufficient for optimizing career trajectories among URM groups.

As a supplement to traditional, dyadic mentoring, academic institutions must create opportunities for network-based "holistic" mentoring, in which mentees at multiple levels of education also serve as mentors to other scholars who are at the same level of education or below while receiving mentorship from mentors who possess a greater level of expertise (e.g., a graduate student mentors undergraduate students while also receiving mentorship from a faculty member; **Figure 1**). In a national study of undergraduate researchers, students who described having significant mentoring relationships with faculty, graduate students, and postdocs in their laboratory, as opposed to only graduate students and postdocs, reported greater scholarly productivity, scientific identity, and likelihood to pursue a Ph.D., suggesting that multi-level mentoring relationships can increase students' sense of belonging and sense of connection to their institution and the larger scientific

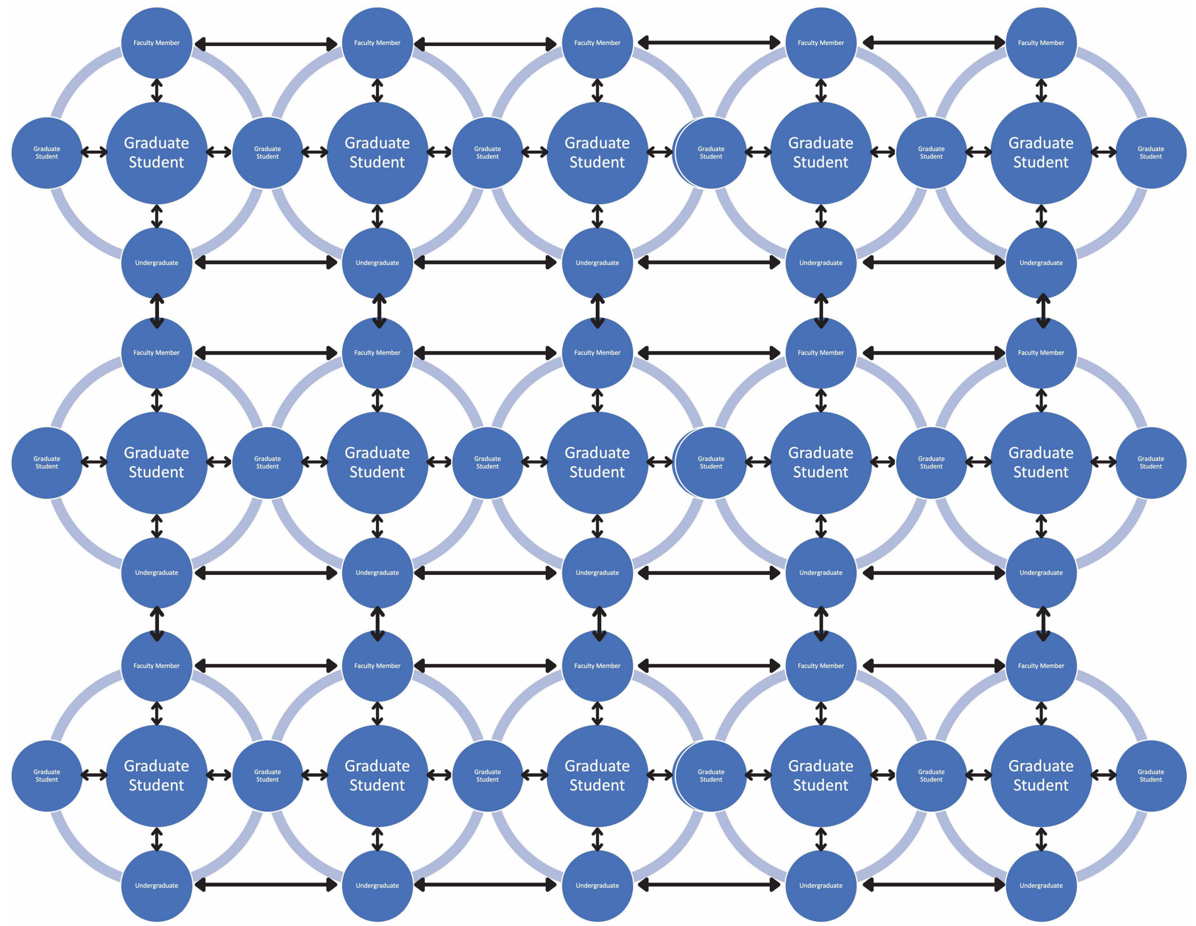


**FIGURE 2 |** Extended network of mentorship throughout an entire academic environment.

community (Aikens et al., 2017; Joshi et al., 2019). In another study, undergraduate students engaged in a peer mentoring network were less likely to consider leaving their university than a comparison group (Collings et al., 2014). In addition, a study of graduate students, postdoctoral fellows, and junior faculty found that scholars who participated in peer mentoring groups in addition to traditional mentoring rated time spent with their mentors as more valuable than those who did not (Lewis et al., 2017). Furthermore, research indicates that positive impacts of mentorship extend beyond the immediate relationship between a single mentor and mentee. For instance, the engagement of postdoctoral fellows in laboratory meetings was found to positively influence graduate student skill development independently of the graduate students' relationships with their PIs, suggesting a "cascading" effect of mentorship (Feldon et al., 2019). These findings emphasize the importance of expanding the way that academic institutions conceptualize mentoring to include more complex structures and relationships than dyads and considering how these relationships exist within and affect extended networks. We envision this extended network of mentoring relationships as a "net" that connects all stakeholders within a given environment (**Figure 2**).

Although holistic mentoring networks hold a large degree of potential, academic institutions must develop an effective strategic plan that will allow such a system to thrive within each of its individual academic departments/colleges/schools. Given our experience implementing mentoring systems for URM groups within STEM higher education, we believe the best approach is for the institution's central governing body to provide a broad set of requirements that each academic department or college (collectively referred to hereafter as "academic units") must follow, leaving it up to the individual academic units to determine how they will implement each of the requirement. At the same time, the central governing body should require each unit to document their efforts and utilize data collection/analysis to evaluate progress. In addition to these requirements, the central governing body should also disseminate suggestions and guidelines based on mentoring literature that are not necessarily required but can help academic units plan and implement mentoring initiatives. Below, we outline several additional recommendations that can guide academic units toward the successful implementation of holistic mentoring systems.

## Recommendation 2: Establish a Committee or Implementation Team for Overseeing Mentoring Within the Academic Unit

The overarching goal of a mentoring implementation team is to help inform, prepare, and support mentors and mentees in developing effective and meaningful mentoring relationships. Implementation teams should consist of a team leader who is familiar with mentoring systems (see section on training below), as well as a diverse array of representatives from varying research areas within the academic unit, racial and ethnic backgrounds, and any other characteristics deemed important by the unit. Team members should understand the contextual influences in the setting and may also be well acquainted with members of the setting (Meyers et al., 2012). Implementation teams must also seek regular and consistent feedback from stakeholders within the academic unit including students, faculty, and staff to inform the decisions made with respect to the mentoring system. Implementations teams can also help reduce negative effects of power differences (see recommendation 5).

## Recommendation 3: Align Mentoring Networks With Existing Formal Advisors/Research Mentors

Academic units will need to determine how to structure their mentoring networks so that they complement the already established dyadic relationships between mentors and mentees and that mentors' advice and guidance for a given mentee do not conflict with another. One approach to addressing this issue is to designate one mentor as a student's primary research mentor (for graduate students, this relationship is typically already in place when they are admitted into a graduate program). Students can then be matched with non-primary mentors either by allowing the student to choose who they work with (from a group of available mentors) or by implementing a matching process based on career and research interest surveys as well as personality inventories. This process allows for matching based on professional, relational, and personal identities, which can increase mentorship quality and reduce impostor phenomenon (Baker et al., 2014; Cohen and McConnell, 2019; Barr-Walker et al., 2020; Chakraverty, 2020). As part of this arrangement, students should understand that they have an obligation to complete work for their primary research mentor before any other mentors. Therefore, non-primary mentoring relationships should not be as task-intensive but rather should focus on providing support, guidance, and connections for mentees.

## Recommendation 4: Implement Practices to Reduce Overcommitment and Minimize Emotional Labor Burden

Overcommitment is rampant in academia given the multi-faceted nature of academic work which includes teaching, writing, conducting research, serving on committees, and of course, mentoring. Lack of healthy balance between work and personal life is consistently cited by academics as a major stressor and has been demonstrated to negatively affect mental health, especially among women, and faculty with children (Solomon, 2011; Bell et al., 2012; Cannizzo and Osbaldiston, 2016). However, faculty of color face additional "cultural tax" burdens when they are asked to take on extra responsibilities to address issues of diversity and inclusion such as serving on DEI committees, educating others about diversity, participating in community service, and mentoring students and colleagues from URM groups (Padilla, 1994; Dancy and Brown, 2011; Akin, 2020). If universities are to successfully implement culturally relevant mentoring without overtaxing mentors of color, both the institution's central governing body and individual academic units must convey to faculty that the responsibility of achieving diversity, equity, and inclusion goals falls on all faculty, not simply faculty who identify with marginalized groups (see section on training for mentors below). As Dancy and Brown (2011) note, the myth that students (and faculty) of color may receive mentoring only from mentors of color can prevent the formation of high-quality mentoring relationships between White mentors and mentees from URM groups. Another factor contributing to the stress of mentoring is that mentoring efforts are rarely recognized, rewarded, or considered in performance review and promotion processes (Montgomery et al., 2014). Academic institutions and individual units should take measures to assess and acknowledge mentors' accomplishments. These efforts may involve creation of both institution and department-level awards for mentoring, as well as re-examining tenure and promotion processes to place a higher degree of emphasis on mentoring outcomes.

To further reduce the burden on faculty, academic units should take stock of all faculty commitments required by the department, college, or school and determine how much each requirement contributes to institution, department, and individual goals. Academic units should consider whether some of these requirements can be reduced or eliminated entirely to allow more time for cultivating students through mentorship. In addition, the central governing body must empower academic units to discover strategies to support faculty who engage in mentorship through merit (i.e., tenure packages, awards, external nominations) and monetary (i.e., start-up packages, program support, department backing) initiatives. This type of support will ensure faculty feel that the academic units value the work they do to grow the demographic of the departments. Given the large variation in the mission, goals, and culture of academic institutions and their discipline-specific academic units, we are aware that there is no single solution that will work for all academic institutions. However, our intention in writing this paper is to encourage individuals within academia to begin having conversations about the role that mentorship plays in creating an equitable academic environment and how efforts can be taken to optimize the effectiveness of mentoring for URM groups.

## Recommendation 5: Put Systems in Place to Address Power Differences

Power differences are often present in mentoring relationships given that one person is typically designated as the mentor and one person is designated as the mentee. Although peer mentoring can mitigate against the negative effects of power abuse in traditional mentoring relationships, peer mentoring is not without its own set of potential problems, including competition among peers, limited professional experiences, and fewer connections (Bussey-Jones et al., 2006). Thus, there is no practical mentoring system that is guaranteed to be free from the risk of abuses of power or from the disadvantages of inexperienced mentors. The limitations present within each system are why we advocate for a holistic mentoring approach that encompasses the benefits of both traditional, dyadic mentoring and peer mentoring approaches while mitigating against the drawbacks of each. Even with this type of system, however, implementation committees must take heed to the disadvantages of dyadic and peer approaches to design a system that minimizes potential limitations. One consideration is to assign peer mentors to one another rather than allowing mentees to choose their own peer mentors. To the extent possible, these assignments should involve the use of quantitative and qualitative data such as field of study, personality fit, potential for cooperation vs. competition, and professional accomplishments. Academic units may also consider creating peer triads or quads to increase social capital and maximize sharing of professional and personal knowledge and support. Finally, mentors (including peer mentors) must receive training that incorporates information about what constitutes an abuse of power, how to recognize and minimize the negative effects of power differences, and how to utilize one's status to help mentees accomplish their career and personal goals.

## Recommendation 6: Provide Training to Mentors and Mentees

Although proper training is critical for mentoring to be carried out effectively in a holistic mentoring system, very little training is typically provided to mentors regarding data-informed best practices for effective mentoring (Pfund et al., 2006; Johnson and Gandhi, 2015). Academic institutions should keep in mind, however, that a "one-shot" training at the beginning of a semester is often insufficient for maintaining trainees' skills over time. In addition to a general orientation that provides the foundational elements of evidence-based mentoring, it is often useful to have shorter, regularly occurring sessions throughout the semester to revisit critical aspects of mentoring, introduce new ideas for mentoring practice, and allow mentors and mentees share insights and ask questions based on their experiences. If mentors' schedules allow, utilizing a curriculum such as *Entering Mentoring* (Handelsman et al., 2005) can be a beneficial way to ensure that mentors acquire skills necessary to help their mentees reach their full potential. Whatever training method is used, it should be based on mentoring literature and include instruction and discussion around key aspects of mentoring practice, such as Pfund et al. (2016) five fundamental attributes of effective mentoring. Based on theoretical models of academic persistence, these five core attributes include research, interpersonal, psychosocial/career, culturally responsive/diversity, and sponsorship. Devoting time for instruction and discussion regarding each of these areas can help mentors understand barriers for URM groups such as stereotype threat, impostor phenomenon, microaggressions, and lack of social connections and help make clear how mentors can play a significant role in reducing the impact of these barriers. Such training can help mentors understand how they themselves may have contributed to these barriers as well as how to help their mentees when they experience them.

Regarding the implementation of training initiatives, the implementation team will need to be trained in evidence-based mentoring approaches or to identify experts who can lead these trainings. One way to ensure that all mentors receive the training is to assign mentees within the program only to mentors who have completed training. Mentors who do not participate in the training can still have primary research mentees but cannot take on additional secondary mentees unless they have completed training. Some academic units may wish to break training participants into small groups that allow for more interactive training workshops, where participants can practice skills with one another. As with small groups of mentees, creating cohorts of mentors is likely to help create camaraderie, comfortability, mutual support, and motivation among mentors (O'Meara et al., 2019).

In addition to mentor training, training for mentees should not be overlooked as a means for maximizing the effectiveness of mentoring initiatives. Students not only need *access to* relationships, but also the *ability to mobilize* those relationships through communication skills, help-seeking behavior, and self-awareness. Research suggests that involving students in training that increases help-seeking and network orientation, such as the Connected Scholars curriculum (Parnes et al., 2020) can have positive impacts on both GPA and student-instructor relationships. For academic units concerned about the time and resources involved in training students, it may be helpful to integrate mentee training within existing structures, such as asking instructors to embed the learning and practice of interpersonal skills into their courses as well as taking advantage of interpersonal skills training opportunities offered by other units on campus such as career and academic success centers. In this way, mentees get the most out of their mentoring relationships while at the same time building skills that they can use throughout their career to create connections and support networks that can help them achieve their goals.

## Recommendation 7: Implement Culturally Responsive Mentoring Practices

Minority students and faculty at majority institutions face challenges that affect their STEM identities. Effective mentorship for URM groups requires mentors to recognize and appreciate the lived experiences of their mentees and understand how barriers impact their participation in STEM. Culturally responsive mentorship acknowledges differences in backgrounds and shows interest in mentees' social identities as well as their science identities (National Academies of Sciences, Engineering, and Medicine, 2019). Mondisa and McComb (2018) suggest that mentors must be aware of key areas of URM mentees' experiences including: (1) differences between their own cultures and the culture of their institution, (2) how mentors identify with their students' worldviews, and (3) racial and ethnic identities in the mentoring relationship. Consideration of mentees' lived experiences and values can help mentors provide the appropriate support for their mentees' goals. With regard to students, affirmation of STEM identities through mentorship can positively impact academic performance (Crisp and Cruz, 2009; Haeger and Fresquez, 2016). Mentors committed to wholly understanding a student or faculty member should invest the time to learning how that individual's background and experiences can influence their academic or job performance. Going beyond encouragement and taking a genuine interest in a mentee socially and emotionally as part of mentoring practice can strengthen mentees' career identities and alleviate common barriers experienced by URM groups (National Academies of Sciences, Engineering, and Medicine, 2019). Academic institutions that intend to be inclusive and promote effective mentorship should provide their faculty and peer mentors with cultural awareness resources and/or trainings to provide them with the necessary tools to support their mentees. The Culturally Aware Mentoring (CAM) training program from the Center for the Improvement of Mentored Experiences in Research (CIMER) offers cultural competency resources for faculty and administrators (Sorkness et al., 2017). Participation in this program could aid mentors with the toolkit to learn and embrace differences experienced by their mentees.

## Recommendation 8: Create Connected Communities

Creating communities in which all members feel valued, respected, and safe is a core underlying component of an effective mentoring system. As Mondisa and McComb (2015) state, social community is created through "dynamic, multidirectional interactions among peers and with faculty in both formal and informal settings." Therefore, academic institutions who hope to create more equitable environments must create opportunities for formal and informal multidirectional interactions, in which participants both benefit from and contribute to their relationships with mentors and peers. Formal interactions may involve classes and regularly scheduled mentoring meetings, while informal interactions may involve recreational gatherings such as attending sporting events or impromptu conversations between peers or colleagues in the hallway. These interactions lead to the development of social support, in which community members are familiar enough with one another that they support each other not only academically, but also personally. Indeed, research demonstrates that sense of community among minority STEM scholars leads to perceived program benefits, which ultimately leads to increased science identity and research self-efficacy (Maton et al., 2016).

One way in which academic units can facilitate community is to create smaller peer groups within the larger community. Smaller peer groups who engage in informal activities together tend to form bonds that allow them to build trust among one another, and in turn, make their campus community feel smaller. Washington and Mondisa (2021) posit that building these types of social communities leads to five important outcomes: (1) connectedness, which includes strength of relationships and sense of belonging, (2) resilience, or the ability to recover from difficult challenges, (3) communities of practice, which are groups of similarly minded individuals who share experiences and social resources, (4) social capital, which refers to the tangible and intangible resources and benefits that result from having personal and professional connections, and (5) satisfaction with one's current academic and social environment. Another beneficial component of mentoring programs that helps to develop a strong sense of community is to create opportunities for alumni to remain involved in various capacities such as providing mentorship to current scholars, serving on informational panels, or attending periodic events. Washington and Mondisa (2021) demonstrated that if there is a strong connection and sense of belonging among participants in the program, alumni are more likely to want to engage with the program even after they leave. Engagement with alumni allows current participants to (1) have access to a larger pool of mentors, (2) grow into fully participating members, and (3) take advantage of the social capital that alumni have to offer as part of their networks.

Finally, providing current participants with a degree of agency in determining how the mentoring program is structured provides an increased sense of connection to the program (Matthews, 2016; Pack and Peek, 2020). Establishing mentee and mentor advisory boards can help to create buy-in for the program, and "crowd-source" solutions to challenges that arise within the program. In addition, collaborating with faculty, staff, and administrators can help build students' skills with regard to designing and planning collaborative learning experiences and can bolster confidence in their ability to positively impact the world around them. Given that mentoring systems will need to adapt and change over time based on emerging research on mentorship, changing populations of students and faculty, shifting priorities of department/institution, and cultural/societal factors, advisory boards that are comprised of people who the program serves can be a critical determinant of whether a mentoring program successfully meets the needs of its participants.

## Recommendation 9: Develop Inter-Institutional Partnerships

Once a system of mentoring is in place, academic units may want to consider expanding the impact of their mentoring networks through strategic partnerships with other academic institutions. As Estrada et al. (2016) point out, there is much to be learned from programs that have demonstrated success in raising the retention and persistence of URM groups in STEM. They suggest that strategic partnerships between programs with similar goals can "ignite institutional transformation. . .and may be the most important factor for producing systemic change" (Estrada et al., 2016). Creating collaborative communities of support that transcend individual institutions allows for an even greater expansion of mentees' social capital by allowing access to mentors with different backgrounds, skills, and connections. By partnering with successful programs, institutions can build on proven strategies and give scholars access to a network of support for academic career stages from undergraduate through junior faculty.

Given that there are multiple types of higher education institutions (research institutions, community colleges, minority-serving institutions, etc.), it is also important to ensure that structures are in place to help students overcome barriers to successful transitions between institutions. For example, students who transfer from an HBCU to a PWI may encounter a less supportive environment and experience greater levels of impostor syndrome, microaggressions, and lower sense of belonging. Thus, it is critical for institutions to consider using the ideas listed in this section with respect to creating opportunities for non-dyadic mentoring, training mentors in culturally sensitive mentorship, and creating tight-knit communities. One set of programs that provides a helpful example for academic institutions seeking to learn how to create communities and inter-institutional partnerships are the Louis Stokes Alliances for Minority Participation (LSAMP). LSAMP are a set of programs funded by the National Science Foundation with chapters at close to 200 colleges and universities throughout the U.S. LSAMP alliances are engaged in successful efforts to increase student retention, graduation, and career excellence for historically underrepresented minority students, and can serve as a great resource for creating successful mentoring programs and tight-knit communities. Given the vast reach of the LSAMP network, it is likely that most academic institutions in the U.S. have an LSAMP program or are close to an institution who does. Academic institutions should consider reaching out to the principal investigators and program managers of their institution's LSAMP programs to learn about their approaches to supporting students from URM groups and to collaborate in developing successful mentoring approaches on a larger scale, as LSAMP programs typically only have funds to serve a relatively small cohort each year.

When discussing inter-institutional collaborations of this type, it is also important to address the criticism that by allowing students to have mentors at other institutions, these extra-institutional mentors may try to "steal" students away from their current institution. We posit that this attitude represents a failure to think about what is best for students. Effective mentors who listen to their mentees' motivations and desires and understand their talent and potential should offer advice based on what will help the mentee achieve their desired career goals. If students prefer to take a path at a different institution, they should have no shame about pursuing that path. Allowing students to have this level of freedom helps to create a well-prepared workforce consisting of individuals who have been presented with several opportunities and have chosen the ones that best fit their passions and skills.

## CONCLUSION

Barriers to retention, graduation, and career success among URM groups in STEM fields continue to persist despite many institutions' efforts to admit more diverse students and hire more diverse faculty, indicating that the supports needed to mitigate these barriers are still lacking. It is critical for academic institutions to act now to implement these supports, especially given the way in which the COVID-19 pandemic has eroded the traditional methods of interaction and increased the occurrence of more impersonal, virtual interactions among students, faculty, and staff. Many students who envisioned college as a social environment that could provide camaraderie, connections, and social support are deciding not to attend given that many of these experiences are diminished in a virtual environment (Ma and Pender, 2021). Experts predict that this trend will only continue even after the pandemic is over, due to increasing costs of tuition, stagnating wages, rising interest rates for student loans, and the increasing popularity of all-online institutions (Parker, 2020; Witze, 2020; Levine, 2021; Levine and Van Pelt, 2021). URM faculty also need strong, supportive connections as social capital is critical for faculty retention and career satisfaction (Bland et al., 2009; Stupnisky et al., 2015). Traditional brick-and-mortar academic institutions have the advantage of being able to provide students and faculty with meaningful interactions and strong network ties that they cannot easily receive through virtual learning. Therefore, creating a sustainable model for higher education must involve the development of strong communities and high-quality relationships that reduce barriers to URM student persistence in STEM, increase the appeal of scientific careers, and provide exceptional support and connections that lead to easily observable positive outcomes for students' careers.

We recognize that the challenges to creating a truly inclusive academic environment are numerous and that there is no single approach to addressing these challenges. In this paper, we have delineated ideas for implementing a mentoring system that incorporates many of the features demonstrated to reduce barriers to success among URM groups in STEM. We are aware that many changes will need to occur in multiple areas on a systemic level and that this process of change will be slow and gradual. However, our intention in writing this article is to convey the need for academic institutions to begin having these conversations about how to address the barriers outlined in this paper and to identify some key considerations for implementing a holistic mentoring system that has the potential to do so. We welcome further discussion on this topic from others in the field and hope to see this issue move toward the forefront of conversations about the need for equitable and inclusive education, STEM diversity, and the future of higher education.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Louisiana State University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

RM, TMW, KG, KW, DB, and IMW wrote sections of the manuscript. RM, KG, and TMW contributed to the organization and editing of the manuscript. All authors contributed to the conception of the manuscript, read, and approved the submitted version.

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# The Effects of Undergraduate Research Experiences as Reported by Texas A&M University System Louis Stokes Alliance for Minority Participation Students

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In 1991, the Texas A&M University System was one of the first six Louis Stokes Alliance for Minority Participation (LSAMP) awardees. In the three decades of programming, several high impact practices (HIP) have been emphasized. One of them, undergraduate research (UR), is discussed. All members of the Alliance are part of the Texas A&M University System and undergraduate research was supported through a variety of initiatives on the Alliance campuses. Data presented chronicle student perspectives. Topics addressed are the impact of involvement in undergraduate research on academic outcomes, interest in further engagement with research, interest in graduate school, and career goals as well as the patterns of research engagement participants experienced and the forms of learning that resulted. These materials are presented regarding an audience that was overwhelmingly underrepresented minority students all of whom were pursuing science, technology, engineering, or mathematics (STEM) degrees. Students reported UR influenced their academic outcomes, further engagement with research, interest in graduate school, and career goals while facilitating learning and skill development. These findings, for URM students from institutions with three different Carnegie classifications that are a predominantly white institution, two Hispanic-serving institutions (HSIs), and a historically Black college or university (HBCU), parallel outcomes reported in the literature for investigations focused on general student populations suggesting that UR benefits are generalizable regardless of institution type and ethnicity/race of the participant. Findings also suggest that these patterns apply regardless of the student's year in school. Material presented details the research elements commonly included in TAMUS LSAMP UR experiences and in which areas students reported the most learning. Thus, this document touches on topics important in addressing development of an adequate, well-trained, and diverse STEM workforce. It also confirms the efficacy of a highly replicable approach to facilitating a HIP, undergraduate research, with students from underrepresented groups.

**Keywords: LSAMP, high impact practice, undergraduate research, underrepresented minority students, STEM**

## INTRODUCTION

The overall goal of the National Science Foundation (NSF) LSAMP program "is to assist universities and colleges in diversifying the nation's science, technology, engineering and mathematics (STEM) workforce by increasing the number of STEM baccalaureate and graduate degrees awarded to populations historically underrepresented in these disciplines: African Americans, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, and Native Pacific Islanders" (National Science Foundation, n.d.). "The Texas A&M University System (TAMUS) Louis Stokes Alliance for Minority Participation (LSAMP) program. . .(focuses on) encouraging and supporting. . .underrepresented minority (URM) STEM majors at. . . Alliance member" (Merriweather et al., 2017, p. 1) institutions. "Formally called TX LSAMP, the Alliance was one of the first six LSAMPs funded by NSF" (Merriweather et al., 2017, p. 1). Since 1991, TAMUS LSAMP has supported over 11,500 "undergraduates for one or more semesters of their undergraduate studies" (Merriweather et al., 2017, p. 1) and Alliance institutions have awarded over 22,000 STEM degrees to URMs.

"Using a carefully conceived suite of opportunities specially designed for URM undergraduate (UG) students. . .the Alliance has" (Merriweather et al., 2017, p. 1) sought improvement of academic success for underrepresented students. Programming and the number of member institutions have varied in the Alliance's 30 years of operation, but the emphasis on academic success and advancement has remained constant. The current member institutions of TAMUS LSAMP are Texas A&M University at College Station (TAMU), a Very High Research Activity institution in the Carnegie Classification System (Indiana University Center for Postsecondary Research, n.d.), Prairie View A&M University (PVAMU), an Historically Black College and University (HBCU) (U.S. Department of Education, 2020), Texas A&M University–Corpus Christi (TAMUCC), an Hispanic-Serving Institution (HSI) (National Center for Education Statistics, 2018), and Texas A&M International University (TAMIU), an HSI (National Center for Education Statistics, 2018). TAMUCC's Carnegie classification is Doctoral Universities: High Research Activity. Both PVAMU and TAMIU are in the Master's Colleges and Universities Larger Program category (Indiana University Center for Postsecondary Research, n.d.). TAMUCC and TAMIU were among the first institutions designated as HSIs as they appear on the Excelencia in Education map of 1994–1995 HSIs, with 35.4 and 93.1% Hispanic student enrollment, respectively (Excelencia in Education, n.d.). Both campuses have continued to have more than 25% of their student population identifying as Hispanic/Latino in each subsequent year [TAMUCC 52% in fall 2020, TAMIU 95% in fall 2020 (National Center for Education Statistics [NCES], 2020a,b)].

Undergraduate research (UR) has been a component through the entire history of TAMUS LSAMP and became a primary emphasis in 2007. UR has a broad base of support in the literature including compendia of practice, process, and outcomes specific to the sciences (Laursen et al., 2010). It is also recognized as a high impact practice in higher education (American Association of Colleges and Universities, n.d.; Kuh and O'Donnell, 2013). Evidence indicates that having conducted research strengthens students' confidence and their understanding of research (Laursen et al., 2010), ability to visualize themselves as an engineer and researcher (Bowman and Stage, 2002; Watson and Froyd, 2007), and that undergraduate research experiences provide the impetus for continuation to graduate school (Schmidt, 2003; Preuss et al., 2020). However, many URM students participating in research at predominantly White institutions like TAMU may find themselves the only URM in their lab, contributing to feelings of isolation (Perez et al., 2018). These circumstances motivated the TAMUS LSAMP to focus on undergraduate research experience as a modality of student support while gathering data to assess its efficacy for students from underrepresented groups on the Alliance campuses.

Contributions made to the literature by this article include confirmation and extension of ideas as well as new information. Overall, the material extends the knowledge base regarding the impacts of UR on URM students by confirming that findings from other studies apply to URM audiences and providing consideration of new material in respect to UR for URM students. The unique contributions of this consideration are establishing that general support of a variety of UR experiences was efficacious for URM students, that the same practices were effective at four institutions in different Carnegie classifications two of which are HSIs and one of which is an HBCU, and inclusion of student reports about the patterns of instruction and training included in their UR experiences.

## PEDAGOGICAL FRAMEWORK

As a grant-funded project focused on improving outcomes for URM STEM students, the instructional framework of TAMUS LSAMP has shifted across the 30 years of continuous operation. Practices emphasized in the earlier cycles became established and institutionalized and new endeavors were added. Examples of early emphases that have been institutionalized are learning communities, community college transfer programming, and summer bridge programming (Merriweather et al., 2017). Undergraduate research has been a particular emphasis with site-specific and Alliance-wide workshops about UR offered and student engagement in UR encouraged and financially supported.

While UR has been emphasized, the possible forms of involvement in it have not been restricted. The spectrum of UR opportunities for STEM students is broad and, due to the established efficacy of undergraduate research, TAMUS LSAMP leaders chose not to limit the possible forms of involvement. In an Alliance comprised of four state universities, one in the Very High Research Activity category, one in the High Research Activity category, and two classified as Master's Colleges and Universities Larger Program (Indiana University Center for Postsecondary Research, n.d.), most forms of UR have been available to TAMUS LSAMP participants including international research experiences (Garcia et al., 2017; Preuss et al., 2020, 2021). The project personnel and their partners at each member institution recruited participants independently in this and all other areas. Thus, a specific framework and pedagogical context in which the UR experiences of the students occurred cannot be detailed. They extend from traditional approaches like inclusion as a student worker in a lab-based investigation to definition of individual projects by students, with the assistance of faculty advisors, that were then executed in international settings. All, though, involved participation in active STEM investigations. Taking this approach, a generalized pattern of facilitation as promotional and informational workshops plus fiscal support, made verification that the impacts of UR noted in the literature would occur for students necessary as activity was not limited to a closely defined context. The information regarding outcomes presented below was gathered to ascertain whether the facilitation pattern was in fact efficacious and whether variation in outcomes existed between institutions or subsets in the pool of participants.

## LEARNING ENVIRONMENT

The learning environment was not restricted. Students were allowed to complete research as part of study abroad programming, were supported as participants in institutionally-based international research efforts, worked on project teams at Alliance institutions (grant-funded and otherwise), and pursued individual projects guided by faculty.

These experiences took place in a wide variety of contexts. They included universities in Europe, South America, and Mexico, American universities within and outside the Alliance, a research center in Belize, national labs, and community-based undertakings. Students participated in a great many of the traditional aspects of a research project (see **Figure 2** and **Table 2**). All these processes were completed under the supervision of faculty from the four institutions or at a university to which the student traveled. The unifying characteristic was participation in an active investigation in a STEM field under the supervision of a university faculty member. In addition to mentoring by faculty, each institution provided use of equipment and supplies as well as, when applicable, support for students to present their work at a research conference.

## METHODOLOGY

Much of the material discussed in this paper was gathered for project evaluation as a means of supporting the development of distinct patterns of programming and assessing their impact. The primary emphasis was on obtaining information about and understanding the impact of each intervention. These data when considered across a period of years facilitated broad analysis of impact.

### Method: Data Sources

Many of the applicable data sources were identified by reviewing the 150 evaluation reports generated for the TAMUS LSAMP project between the 2007–2008 and 2019–2020 school years. This included quantitative data like participant counts and responses to survey questions, and qualitative data in the form of short answers to open-ended survey questions and interview and focus group transcripts. Journal articles published regarding the TAMUS LSAMP project were also consulted as sources of information (Graham et al., 2001; Garcia et al., 2017; Merriweather et al., 2017; Preuss et al., 2020) as were programmatic and institutional data.

To arrive at aggregated sets summarizing findings over a period of years, elements of related data sets were combined. This was a simple process when the same questions were used for several years. Interruptions to patterns occurred when the project felt a construct under investigation had received sufficient consideration, when the program shifted emphases or began support of new patterns of programming, or when questions were determined to be ineffective for producing the intended result. Most shifts in emphasis occurred in conjunction with the 5-year project funding cycle. Brief descriptions of how data were combined and when changes in data patterns occurred will precede discussion of findings from each of the data sets.

Much of these data came in the form of student self-reports and addressed experience, self-assessment, and personal opinions. Given the intention of evaluating LSAMP programming using student self-assessment and feedback regarding personal experience, control groups were not included. Thus, the majority of information considered herein is descriptive.

Two streams of data regarding undergraduate research will be presented and discussed. The first is survey responses from LSAMP-supported students at three of the four Alliance institutions who participated in UR from the 2007–2008 school year through 2015–2016 (TAMIU became an Alliance member in 2019). The second is findings from surveys of Alliance students who completed presentations about their research at the annual TAMUS LSAMP research symposium. The information from students who presented their research, while gathered in 2019, provides insight regarding the responses gathered from 2007 through 2016. They have been employed in this way as the students, while not the same parties, participated in the same processes by which UR was facilitated at and through the same institutions.

## Method: Ethics Statement

Project implementation and assessment was completed in alignment with applicable federal and state regulations and guidelines for grant funded endeavors. All evaluation and project data gathering were completed in accordance with Institutional Review Board (IRB) approved protocols. A project IRB protocol was maintained at Texas A&M University in College Station, where the TAMUS LSAMP offices are located, and a separate evaluation IRB protocol was maintained at West Texas A&M University where the evaluation unit was housed.

## Method: Data Analysis

Data analysis had both historic and current patterns. The original data or detailed summaries of participant responses were processed for project evaluation and later accessed to determine whether and how the material overlapped and could be combined for this article. Since this process varied slightly for each source, a brief account of what transpired will precede discussion of each form of data. Once identified, data sources were combined as applicable. Quantitative analysis completed was descriptive and tabular. Applicable qualitative data were aggregated from original sources and underwent an open coding process (Kolb, 2012). Four volunteers from the TAMUS LSAMP implementation team were provided de-identified sets of aggregated comments. A brief written set of instructions was provided to each coder and a Zoom call was held to allow them to ask questions of the evaluator who set up and participated in this process. The four independently developed codebooks were reconciled by the evaluator and the reconciled codebook was sent out for comment and approval by the coding team. Suggestions made regarding the reconciled codebook were addressed and resolved as a group.

# RESULTS

## Survey Responses 2007–2016

From the 2007–2008 through the 2015–2016 school years, TAMUS LSAMP participants were asked a series of questions about their undergraduate research experience. The topics were based on the project goals and impacts of UR documented in the literature, some with broad support and others that have received less consideration.

The influence participating in UR has on interest in graduate school is a frequently investigated topic (Craney et al's., 2011; Eagan et al., 2013; Conrad et al., 2015; Chang et al., 2016; Frederick et al., 2021). Impact on academic outcomes (Hunter et al., 2006; Lopatto, 2007; Linn et al., 2015), understanding of course content (Jonides et al., 1992; Kardash, 2000; Flaherty et al., 2017), performance in courses (Jonides et al., 1992; Lopatto, 2007; Sell et al., 2018), and career choice (Russell et al., 2007; Chang et al., 2016; Kilgo and Pascarella, 2016; Powers et al., 2018) have also received significant attention. Other topics are UR impact on the student's interest in continued involvement with research (Seymour et al., 2004), interest in courses (Seymour et al., 2004), and confidence in choice of major (Seymour et al., 2004). The TAMUS LSAMP data include responses from 358 students, the vast majority of whom were URM students (90.4% of participants identified as URMs from the 2013–2014 through 2019–2020 school years). It considers all the topics listed above providing the potential to confirm efficacy of general support of UR for URM students at institutions of different types. The relative lack of diversity in STEM fields makes this a critical point as Carpi et al's. (2017) suggest undergraduate research "serves as a powerful equalizer. . .to address the longstanding under-representation of minorities in the sciences" (p. 169).

The data summarized in **Table 1** were gathered with surveys and for the first 3 years, the queries remained unchanged. All the queries addressed impact participation in UR had on the informant. In the 2010–2011 school year, two questions were eliminated and another was added and the response pattern was shifted from a four-point Likert scale (strongly disagree, disagree, agree, strongly agree) to a five-point Likert scale (strongly disagree, disagree, neither agree or disagree, agree, strongly agree). While these changes presented challenges to consideration of the nine years of data as one unit, the differences facilitate comparison of responses from two similar groups in respect to the same questions and elucidation of the earlier group of responses as the addition of a neutral response increased precision. Both groups were large, 175 students and 183 students, respectively, and the response rates were high, ranging from 71.4 to 100%. Even at the lowest levels, 71.4 and 84.2% response rates, the results meet a 95% confidence level with a 4.7 and 3.15 confidence interval, respectively (calculated at 50%), and at the highest level they include responses from every party asked to participate. Thus, even at its weakest points, these data are significant.

The responses can be rank ordered by level of agreement (combining responses of Agree and Strongly Agree).

- Interest in continuing with research (89.4%).
- Effect on academic life (83.2%).
- Increased interest in classes (82.2%).
- Increased understanding of course content (81.3%).
- Helped with career choice (75.4%).
- Improved performance in classes (61.8%).
- Increased interest in graduate school (61.2%).
- Increased confidence in choice of major (44.2%).

These outcomes align with findings from prior investigations (see details below), although most of the results other researchers published were for general student populations rather than URM students.

Russell et al. (2007) reported that UR "helped clarify students' interest in research" (p. 548) and 89.4% of the TAMUS LSAMP informants noted interest in continuing with research. Jonides et al. (1992) reported UR participants completed more credit hours than same aged peers while Bowman and Holmes (2018) and Sell et al. (2018) reported association with higher GPAs, findings that align with the LSAMP survey's general category, effect on academic life, which 83.2% of informants affirmed. Seymour et al. (2004) found "shifts in attitudes to learning" (p.

**TABLE 1 |** Survey responses 2007–2016.

| Participation in LSAMP-supported research. . . | Period | Response Rate | SD | D | NAD | A | SA |
|---|---|---|---|---|---|---|---|
| . . .had no effect on my academic life. | 1st 3 years | 89.1% | 36.8% | 46.4% | N/A | 12.0% | 4.8% |
| . . .increased my interest level in classes in my major field. | 1st 3 years | 98.3% | 2.3% | 11.6% | N/A | 51.7% | 34.3% |
| | Next 6 years | 100% | 2.2% | 4.4% | 13.7% | 44.8% | 35.0% |
| | Cmbnd | 99.2% | 2.2% | 7.9% | * | 48.2% | 34.6% |
| . . .increased my understanding of the content in classes in my major field. | 1st 3 years | 98.3% | 2.3% | 13.4% | N/A | 55.2% | 29.1% |
| | Next 6 years | 84.2% | 0.0% | 0.6% | 4.5% | 63.0% | 31.8% |
| | Cmbnd | 91.1% | 1.2% | 7.4% | * | 58.9% | 30.4% |
| . . .improved my performance in classes in my major field. | 1st 3 years | 98.3% | 2.3% | 27.3% | N/A | 51.7% | 18.6% |
| | Next 6 years | 100% | 2.7% | 2.7% | 39.9% | 36.6% | 18.0% |
| | Cmbnd | 99.2% | 2.5% | 14.6% | * | 43.6% | 18.2% |
| . . .made me want to continue my involvement in research. | 1st 3 years | 98.3% | 0.6% | 6.4% | N/A | 41.3% | 51.7% |
| | Next 6 years | 100% | 1.1% | 1.6% | 9.8% | 39.9% | 47.5% |
| | Cmbnd | 99.2% | 0.8% | 3.9% | * | 40.2% | 49.2% |
| . . .increased my confidence in my choice of major. | 1st 3 years | 98.3% | 0.6% | 9.3% | N/A | 40.7% | 49.4% |
| | Next 6 years | 100% | 1.6% | 1.6% | 10.4% | 43.2% | 43.2% |
| | Cmbnd | 99.2% | 1.1% | 5.3% | * | 42.0% | 46.2% |
| . . .helped me in my career choice. | 1st 3 years | 97.7% | 1.8% | 19.3% | N/A | 49.7% | 29.2% |
| | Next 6 years | 100% | 1.6% | 4.9% | 19.7% | 37.2% | 36.6% |
| | Cmbnd | 98.9% | 1.7% | 11.7% | * | 42.7% | 32.7% |
| . . .increased interested in pursuing a graduate degree. | 1st 3 years | 71.4% | 1.6% | 12.8% | N/A | 31.2% | 54.4% |
| | **Period** | **Response Rate** | **NAA** | **AL** | **SW** | **A Lot** | **AGD** |
| . . .contributed to interest in going to graduate school. | 1st 3 years | 99.5% | 4.3% | 5.3% | 26.4% | 26.0% | 38.0% |

*n for the first 3 years = 175, next 6 years = 183, combined = 358. SD, strongly disagree; D, disagree; NAD, neither agree or disagree; A, agree; and SA, strongly agree; NAA, not at all; AL, a little, SW, somewhat; A lot, a lot; AGD, a great deal. * = value cannot be calculated as NAD was not included as a possible response during the first 3 years.*

493) associated with UR participation and Flaherty et al. (2017) reported "increased. . .confidence in. . .perceived knowledge of science" (p. 701), both of which align with the impact on academic life just noted, the 82.2% of LSAMP informants who reported increased interest in classes, the 81.3% who reported increased understanding of course content, and the 61.8% stating their performance increased in classes. Increased confidence in choice of major had the lowest affirmation level among TAMUS LSAMP informants, 44.2%, but is related to career choice and interest in graduate school which have strong support in the literature and moderate to high affirmation rates for TAMUS LSAMP, 75.4 and 61.2% respectively.

Craney et al's. (2011) state that UR had a "key specific outcome. . .clarification and reinforcement of a graduate school career path" (p. 107) while also being associated with "more favorable attitudes toward research as a career option" (p. 107). Flaherty et al. (2017) found contribution toward "clarification of career goals" (p. 701) which parallels earlier results from Seymour et al. (2004) and Thiry et al. (2011). Important for this consideration, Carpi et al's. (2017) noted that UR "increases career ambitions for underrepresented students in STEM" (p. 169) and "is seen to have a transformative effect for many students at MSIs" (p. 169). The TAMUS LSAMP informant responses align with the impacts noted by Seymour et al. (2004), Craney et al's. (2011), Thiry et al. (2011), Carpi et al's. (2017), and Flaherty et al. (2017).

A related construct, UR impact on interest in graduate school, also has strong support in the literature. Lopatto (2007), Eagan et al. (2013), and Chang et al. (2016) all note impact with Eagan et al. stating "participation. . .significantly improved students' probability of indicating plans to enroll in a STEM graduate program" (p. 683). Borrego et al. (2018) associated this with increased self-efficacy; "for every one-unit increase in students' scores on the Self-efficacy scale, they were over eight times more likely to plan to enroll in a master's program relative to not attending graduate school, and they were 13 times more likely to enroll in a Ph.D. program relative to not attending graduate school" (p. 154). The query listed at the bottom of **Table 1** provides insight into the extent to which UR contributed to interest in graduate school for TAMUS LSAMP respondents. A total of 63.6% of informants indicated it contributed "A lot" or "A great deal." Only 4.3% of respondents indicated it did not contribute.

That all of the above occurred for TAMUS LSAMP students who participated in UR is notable. That all the impacts applied to a population that was over 90% URM students, is highly encouraging and supports Carpi et al's. (2017) assertion that UR can be "a powerful equalizer. . .to address the longstanding under-representation of minorities in the sciences" (p. 169).

## Survey Responses 2019

The TAMUS LSAMP project sponsors an educational, networking, and research presentation symposium on an annual basis. The 2018–2019 symposium was held in the spring of 2019 and the 2019–2020 symposium was held in conjunction with the TAMUS Annual Pathways Student Research Symposium

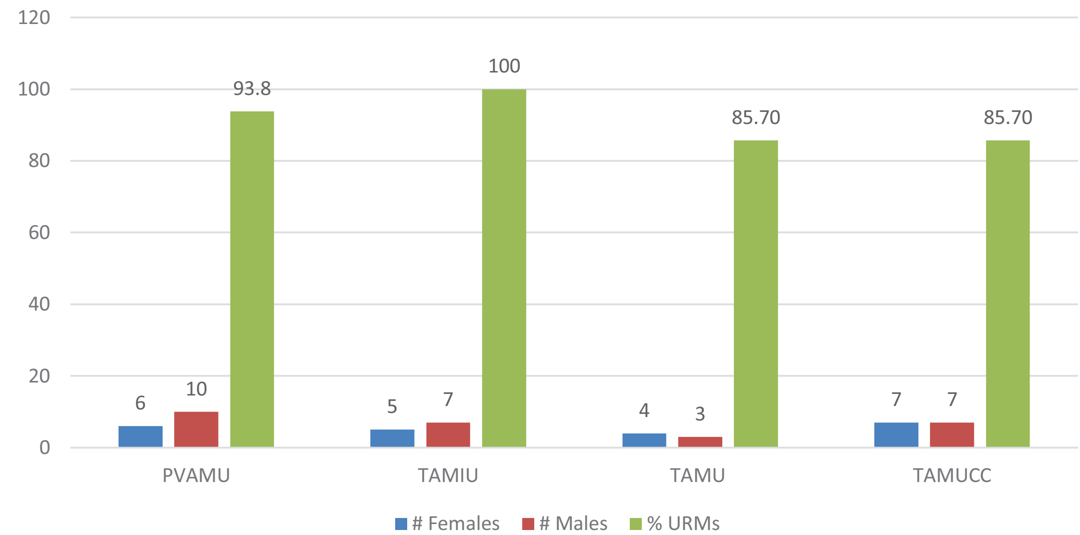


**FIGURE 1 |** Number of female and male students and percentage of underrepresented minorities (URMs) by campus for 2019 survey.

in the late fall of 2019. All students who had been supported by LSAMP to complete UR and who presented about their project at one of the two symposia were surveyed. There were 67 students representing all four Alliance institutions. A total of 49 submitted survey responses. This meets a 95% confidence level with a 7.31 confidence interval when calculated at 50%. **Figure 1** provides a breakdown of gender and percentage of URM participants by campus for 2019 survey respondents.

Demographics gathered about these students confirmed that the sample had nearly the same distribution of females and males as the total population. All Alliance institutions were represented although students from TAMU, the largest group, were the least likely to respond (33% participation), with TAMIU at 65%, PVAMU 80%, and TAMUCC 100% participation. The counts of respondents per institution ranged from seven (TAMU) to 16 (PVAMU). There were 23 male and 26 female informants (males were undersampled; 46.9% of sample and 58.8% of population). There were 28 students who identified as Hispanic/Latino and 21 who did not. Five of the Hispanic students identified with more than one racial group and the remaining students' racial identities were African American ($n$ = 13), Asian ($n$ = 4), Hispanic/Latino ($n$ = 21), Native Hawaiian/Pacific Islander ($n$ = 1), and White ($n$ = 4) with one informant selecting "I do not care to answer." The only ethnic or racial category that was not balanced across the institutions was African American as 12 of 13 students describing themselves this way attended PVAMU. Most of the informants were upper-level undergraduates. Four were sophomores, seven were juniors, and 38 were seniors. Thus, 81.6% of informants identified as URM students with the sample distributed across all four institutions.

The questions asked on the survey address topics about which there is limited evidence in the literature, especially in respect to URM populations. These are length and continuity of experience in research, number of investigations the students contributed to, the level of independence experienced in research settings, whether the UR experience had a perceivable training pattern, and the tasks in which the student was engaged. There is also evidence regarding impact on future plans with the potential to shed additional light on the topics in the 2007–2016 data.

### Length and Continuity of Experience in Research

Respondents were asked to select all that apply from a list of options about when their experience with research began. Their options started with a statement that they had research experience prior to coming to college and included each year of undergraduate study.

- Three (3) noted experience prior to attending college.
- Four (4) stated they had research experience as freshmen.
- Seventeen (17) indicated research experience as sophomores.
- Seventeen (17) noted research experience in their junior year.
- Twenty-two (22) had research experience during their senior year.
- Approximately 20% ($n$ = 10) of the students reported involvement with research in two or more years of undergraduate study.

The three students who reported having research experience prior to entering college may have misunderstood the question as they did not report continuing experience following that by selecting additional responses to the question. It is possible that they understood the question to be asking when their experience in research began.

### Number of Investigations to Which Students Contributed as Undergraduates

The LSAMP Symposium presenters were asked about the number of research investigations to which they had contributed during their undergraduate career. This was a multiple-choice question for which one answer could be selected. The answers ranged from one study to four or more. Responses occurred in each category with 17 indicating experience with one research project, 16 two projects, 10 three projects, and six reporting work on four or more projects.

The three students who reported research involvement before college but not during college also indicated they contributed to two, three, and four or more studies. While the number of studies may be a function of the lab or faculty mentor rather than the student, this pattern appears to support the idea that the students misunderstood the earlier question about when they were involved with research thinking they were being asked for a "start date" rather than periods of involvement. The response pattern also suggests that URM students who engage in UR become motivated to continue in UR as 65.3% of respondents contributed to two or more studies. Thiry et al. (2012) note the significance of the LSAMP student reports regarding length, continuity, and number of investigations students worked on during UR when they stated their "findings suggest that students benefit from multi-year UR experiences" (p. 260).

### Relative Level of Independence in Research

Respondents were asked to respond to a multiple-choice question about the level of independence they had experienced in research. To the best of the authors' knowledge, this query is unique to the TAMUS LSAMP data set. Students were permitted to select all that applied to their circumstances from a list of descriptive statements. The choices presented are listed below with the number of responses in parentheses. Two students did not respond to this question.

- As a student worker completing basic tasks (21 students).
- As a student who was provided guidance to autonomously complete tasks (19 students).
- As a student member of a research team in which I could contribute ideas (20 students).
- As an independent researcher operating with assistance from a faculty member (18 students).
- As a completely autonomous researcher defining and completing my own projects (four students).

The four students noting autonomous research were from three different institutions. Many of the students who reported earlier involvement with research also reported multiple levels of responsibility/independence ($n = 22$). Students reporting multiple forms of responsibility were upper-level undergraduates, with one exception (one sophomore, two juniors, 19 seniors). These patterns suggest that faculty supervisors facilitate increased levels of independence in processes as students gain experience in research.

### Relationship of Research Experience to a Training Pattern

Informants were asked about the relationship of their research experience to a set of education goals or a training pattern, specifically whether they perceived that a deliberate training pattern had been enacted. There were three possible responses and students could select more than one to allow for expanded responsibility or involvement in several projects. The prompts, with associated counts of responses, follow. One student chose not to respond to this question.

- Been primarily at one level of responsibility (11 students).
- Involved learning different tasks and having several areas of responsibility for a project but these were assigned based on project needs rather than my educational goals (30 students).
- Involved a sequence of steps and variety of activity that was deliberately planned as training pattern (13 students).

Five students selected more than one response. Two indicated primarily one level of responsibility and involvement in different tasks as assigned. Two others noted different tasks being assigned without reference to personal goals and a deliberately planned sequence. One selected all three options. These persons were all upper-level students with involvement in two or more studies. While material presented above suggests increases in independence in research as student experience increases, this set of responses indicates approximately 75% of the students did not perceive a deliberate training pattern as the basis of their experience. Craney et al's. (2011) reported "research advisor[s] "provided needed instruction/direction" for 79% of the participants" (p. 103). Craney et al's.'s (2011) prompt is superior to that used in the TAMUS LSAMP survey as it measures provision of needed assistance rather than perception of a structured training program. The TAMUS survey results, while informative regarding student perceptions and suggesting that faculty could provide more or more explicit explanation of the purposes and process in training the students undertaking certain responsibilities, does not address the more important issue, provision of appropriate guidance/assistance.

### Practical Experience Achieved in Research Settings

Respondents were also asked to select all responses that applied to their experience from a list of 21 types of engagement in research projects. The 20th was "None of the above" and the 21st was "Other" followed by the opportunity to provide an alternate response in a text entry box. **Figure 2** lists all the fixed-answer responses for which submissions were received and the number of responses in each category. No student selected "none of the above" and only one selected "Other" and submitted the explanation "prototyping."

**Table 2** lists the responses of the students in groups formed based on the natural breaks in the response counts. There were four places at which there were differences of three or more points creating a five-tier pattern. Statements for which there was the same number of responses are listed in the order in which they occurred on the survey.

Several generalizations are possible based on the material presented in **Figure 2** and **Table 2**. First, it appears the students were involved, as undergraduates, in many important aspects of research projects. Second and as an extension of the first, they were receiving a broad introduction to research. Third, the students were more likely to report involvement in commonly understood major elements of research like designing the question, completing statistical analysis, and summarizing

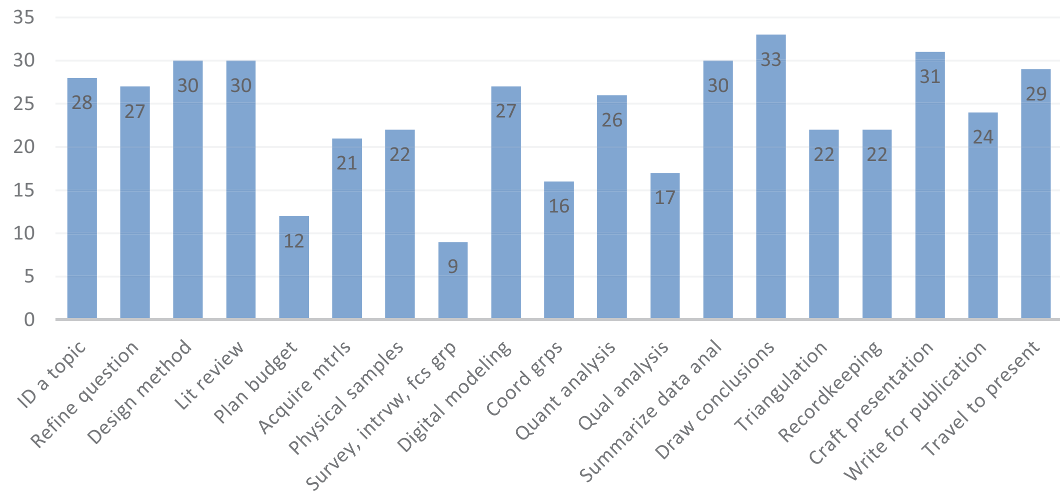


**FIGURE 2 |** Response counts for elements of research experienced in undergraduate research.

**TABLE 2 |** Grouping of research experiences by response rate.

| | |
|---|---|
| Reported by 26 or more students | – Drawing conclusions based on results from data analysis.<br>– Crafting presentation materials summarizing research outcomes (posters, PPT slides, graphics).<br>– Designing a methodology for the investigation.<br>– Completing an investigation of relevant material in journals and other publications.<br>– Summarizing results from data analysis verbally or in writing.<br>– Traveling to present at a conference sponsored by a professional organization.<br>– Identifying a research topic to pursue.<br>– Refining the research question.<br>– Running digital modeling, synthesis, tests, etc.<br>– Completing statistical analysis of quantitative data (e.g., counts and ratings). |
| Reported by 21–24 students | – Writing material summarizing research outcomes for publication.<br>– Gathering and processing physical samples.<br>– Comparing results from different data sets for one project (i.e., triangulation) to reach or support conclusions.<br>– Recordkeeping.<br>– Planning the acquisition of necessary supplies and materials. |
| Reported by 16–17 students | – Completing analysis of qualitative data (e.g., things people said or wrote).<br>– Coordinating the activity of a group of people. |
| Reported by 9–12 students | – Planning the project budget.<br>– Gathering and processing information provided by people on surveys, in interviews, in focus groups, on video, etc. |
| Reported by 1 student | – Other: prototyping. |

research findings than in the detailed and skill dependent activities like collecting physical samples and conducting interviews or focus groups (although the latter may have been impacted by the students being STEM majors). The synopsis of qualitative findings confirms these patterns. They chronicle and parallel learning in 12 of 13 areas reported in response to a quantitative query (**Figure 3**).

Comparing the areas in which students reported the most learning (**Figure 3**), those with 25 or more responses of "Learned a lot," to the most frequently reported research elements included in the student experiences (**Figure 2**), those with 26 or more responses, results in a thumbnail sketch of a UR experience in TAMUS LSAMP. It also suggests that the pattern is effective as most students reported they "Learned a lot" or "Gained some experience" in the processes noted. The thumbnail sketch of a TAMUS LSAMP UR experience includes the following elements: (1) identifying a topic, (2) refining the research question, (3) designing an investigative method, (4) completing literature review, (5) digital modeling, (6) performing quantitative analysis, (7) summarizing findings from analysis, (8) drawing conclusions, (9) preparing presentation materials, and (10) traveling to present findings.

## Research Experience Impact on Student Plans

A prompt "My involvement with research has impacted my thinking about" was followed by four possible responses. Informants could select all that applied. The categories with counts of responses submitted are listed below.

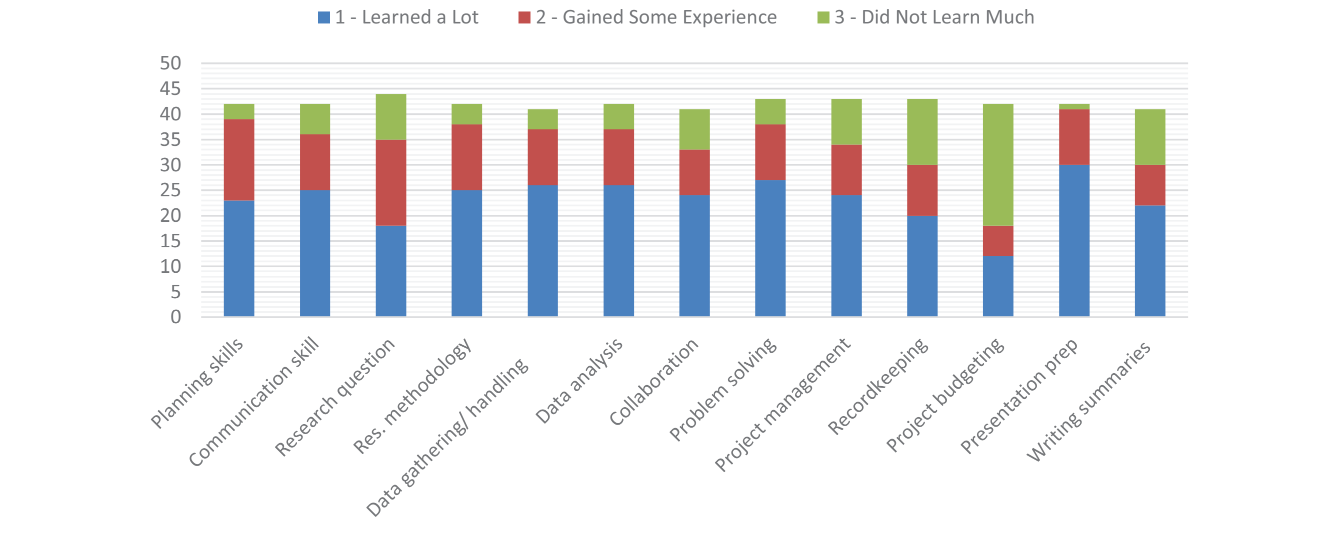


**FIGURE 3 |** Learning reported regarding research processes.

- College course selection (selected by 19 students).
- Identifying a mentor or person from whom I can solicit advice (selected by 29 students).
- My career goals (selected by 39 students).
- My intentions regarding graduate school (selected by 32 students).

The relative academic level of the students in the sample, 45 of the 49 were juniors or seniors, may have impacted the course selection responses. Students at higher academic levels are more likely to have reached a more degree-specific and less flexible set of course options.

The ability to identify a mentor who can provide advice is beneficial to students (Craney et al's., 2011). Frederick et al. (2021) assert "the benefits conferred through mentoring relationships with faculty are among the most important advantages undergraduate students gain through co-curricular research" (p. 2). At the opposite end of the spectrum, Powers et al. (2018) point out that "negative experiences (such as. . .poor mentors) caused some students to change career or education plans" (p. 3). That 59.2% of informants felt they had found, through involvement with UR, a person who could and would provide them advice is, therefore, a positive outcome. Response patterns for the other items, career goals and graduate school intentions, parallel findings from the 2007 to 2016 data described above and align with impacts noted there from the work of other researchers (*career goals*: Seymour et al., 2004; Craney et al's., 2011; Thiry et al., 2011; Carpi et al's., 2017; Flaherty et al., 2017; *graduate school*: Lopatto, 2007; Eagan et al., 2013; Chang et al., 2016; Borrego et al., 2018).

## Learning Experienced Through Research Participation

The survey respondents were also asked to rate 13 statements as: (1) an area in which you learned a lot, (2) an area in which you gained some knowledge or experience, or (3) an area in which you did not learn much or gained little to no experience. **Figure 3** shows the response pattern for this question.

The counts in **Figure 3** do not total 49 as some students did not rate all the prompts and several completed the question incorrectly.

The responses from TAMUS LSAMP participants to this question reflect patterns in the literature. Craney et al's. (2011) noted development in three skill areas, communication, problem-solving, and forming a research question. Lopatto (2007) reported advancements in understanding the literature, data analysis, communication skills. Especially relevant, Frederick et al. (2021) found UR "strengthened. . .research skills" (p. 5) in a study focused on Hispanic/Latinx students. TAMUS LSAMP findings proved similar to these and Kardash's (2000) findings in which "the extent to which14 research skills were enhanced" (p. 191) was addressed with some advancing to a greater extent than others.

## Most Valuable About Research Participation

One of the final questions asked of the Symposium presenters was what had been most valuable about their experience in undergraduate research. The responses were coded by a group of four TAMUS LSAMP personnel. Summaries of the respondents' statements based on codings are listed below. These parallel and support the findings described above and confirm that the impacts of UR described in the literature, also noted above, were replicable with a predominantly URM student population at four distinct universities.

- UR increased interest in research and graduate school.
- UR increased confidence and self-efficacy particularly in research settings and in respect to being a worthy graduate school candidate.
- UR provided opportunities to apply classroom learning through active involvement in real world settings, to be mentored, to have role models, to network with faculty

and student peers, to participate in related workshops, and to present research findings.
- UR facilitated development and honing of personal and professional skills: (1) being responsible, (2) being organized, (3) collaborating, (4) planning, discussing, and executing research activity, (5) technical writing, and (6) planning and completing research presentations.

To summarize, participants saw the value of participating in UR as expanded perspectives, improved motivation, receiving a preview of "what grad school is like," receiving insight into ways to fund graduate school, and learning about a variety of STEM career paths. Of the 67 Symposium undergraduate attendees, at least 61 (91.0%) have graduated with bachelor degrees. At least 19 of these 61 graduates (31.1%) have enrolled in graduate school.

## SUMMARY DISCUSSION

Findings suggest that UR sponsored through TAMUS LSAMP achieved its "potential as a powerful programmatic and pedagogical tool" (Kilgo and Pascarella, 2016, p. 575). This is especially the case as only four of the studies cited herein specifically targeted understanding UR impacts for URM students, yet the relevant findings from all studies were replicable in an LSAMP setting and at four different universities indicating potential to generalize UR outcomes in the literature to URM audiences.

Some researchers of UR have reported different outcomes by gender (Kardash, 2000) while others have not (Lopatto, 2007; Bowman and Holmes, 2018), the 2019 data set which included demographic information, showed no significant differences in effect by gender, ethnicity, or race. All the benefits of UR were uniformly realizable for all students in the 2019 sample highlighting UR's potent to serve "as a powerful equalizer. . .to address the longstanding under-representation of minorities in the sciences" (Carpi et al's., 2017, p. 169) as well as that of females.

Seven of the eight perceived benefits of UR assessed in the 2007 to 2016 data were reported by over 60% of the respondents. Six of these benefits, (1) increased interest in continuing engagement with research, (2) increased interest in classes, (3) increased understanding of classes, (4) increased performance in classes, (5) increased interest in graduate school, and (6) better informed career choices, were also present in the quantitative and qualitative data sets from 2019. These findings affirm that the general pattern of facilitation of UR was effective in producing the benefits noted in the literature and for students at a variety of institution types who were predominantly URMs. These perceived benefits were also reported by sophomores, juniors, and seniors, so the age of the student does not appear to limit potential for impact (Preuss et al., 2021). This is valuable information as the simple pattern enacted can be replicated at any institution of higher education.

Most of the informants began involvement in undergraduate research as juniors and seniors, but this could be a function of the LSAMP recruiting patterns. For example, TAMUCC focuses their efforts on students in their junior and senior years. Even with engagement beginning in the last 2 years of undergraduate study for most informants, UR involvement extended across more than 1 year for many. Their experiences were distributed across four different types of engagement, from performing basic research tasks to being fully autonomous, although autonomous activity was limited to 8% of respondents. Most frequently, the students learned tasks as needed for a project but approximately one quarter reported perceiving a "deliberately planned sequence of steps and variety of activity" as a training pattern. That, however, is not the same as there not having been a deliberate training pattern and use of Craney et al's. (2011) prompt, or something similar, about receiving needed assistance and guidance would have been a preferable query.

The elements of student engagement with research during their UR experience are reported in **Figure 2** and **Table 2**. Linn et al. (2015) state that "the ideas that students learn (in UR) are often isolated or fragmented rather than integrated and coherent. . .(and) Rigorous research is needed to identify the ways to design research experiences so they promote integrated understanding" (p. 628). They suggest that "powerful and generalizable assessments that can document student progress, help distinguish effective and ineffective aspects of the experiences, and illustrate how students interpret the research experiences they encounter" (p. 628) are needed. While TAMUS LSAMP did not attempt to create generalizable assessments, the outcomes reported by students do provide evidence regarding student progress, where the greatest learning took place indicating in which areas general facilitation of UR was effective, and the self-reported data provide insight into how the students interpreted their experience. Beyond having between 61 and 95% of respondents reporting learning in 12 of 13 areas (**Figure 3**), students: (1) were involved, as undergraduates, in many important aspects of research projects, (2) received a broad introduction to research, and (3) were more likely to report involvement in commonly understood major elements of research. They saw the value of participating in UR as expanded perspectives, improved motivation, receiving a preview of "what grad school is like," receiving insight into ways to fund graduate school, and learning about a variety of STEM career paths.

Comparison of the areas in which students reported the most learning (**Figure 3**), those with 25 or more responses of "Learned a lot," to the most frequently reported research elements included in the student experiences (**Figure 2**), those with 26 or more responses, results in a thumbnail sketch of a UR experience in TAMUS LSAMP. It also suggests that the pattern is effective as most students reported they "Learned a lot" or "Gained some experience" in the processes noted. These could be the basis of further investigation at an increased level of rigor as suggested by Linn et al. (2015). The thumbnail sketch of a TAMUS LSAMP UR experience includes the following elements: (1) identifying a topic, (2) refining the research question, (3) designing an investigative method, (4) completing literature review, (5) digital modeling, (6) performing quantitative analysis, (7) summarizing findings from analysis, (8) drawing conclusions, (9) preparing presentation materials, and (10) traveling to present findings.

This pattern, and the reported gains in learning/skill, align with results reported in the literature (Kardash, 2000; Lopatto, 2007; Craney et al's., 2011; Frederick et al., 2021), but demonstrate potential to generalize them to UR completed by URM students and conducted at Minority-Serving Institutions.

The ability to identify a mentor is another commonly cited outcome from involvement with UR (Craney et al's., 2011; Linn et al., 2015; Powers et al., 2018). Frederick et al. (2021) asserted "the benefits conferred through mentoring relationships with faculty are among the most important advantages undergraduate students gain through co-curricular research" (p. 2). This benefit was realized for many of the LSAMP participants as 59.2% of informants felt they had found, through involvement with UR, a person who could and would provide them advice.

## PRACTICAL IMPLICATIONS

TAMUS LSAMP seeks to serve underrepresented students at four Alliance institutions. These fit in three different Carnegie classifications. The Very High Research category institution, TAMU, is a predominantly White institution. The other partnering institutions are an HBCU and two HSIs. The outcomes described above existed for students of each institution type. It is notable that there were no differences in outcome by institution type, gender, ethnicity, or race. This confirms assertions made in Laursen et al.'s (2010) and other sources (American Association of Colleges and Universities, n.d.; Kuh and O'Donnell, 2013) about the efficacy of undergraduate research in general and for students from underrepresented groups. It also suggests that the general facilitation pattern enacted by TAMUS LSAMP would be effective at many other institutions given uniform effects over a 13-year span at several universities with differing Carnegie classifications and student populations. Given the need to expand the STEM workforce in the United States and the limited diversity in the existing STEM workforce (Bayer Corporation, 2012; Linley and George-Jackson, 2013; Collins, 2018; National Science Foundation, 2018), the ability, demonstrated by TAMUS LSAMP data, of UR to act "as a powerful equalizer. . .to address the longstanding under-representation of minorities in the sciences" (Carpi et al's., 2017, p. 169) as well as that of females is of critical importance.

## LIMITATIONS

The data discussed were student self-reports and control group data were not gathered thus the degree to which the outcomes vary from those for students not participating in the LSAMP programming is unknown. Demographic information included in the 2007–2016 data set could not be reintegrated with the survey responses eliminating the potential to disaggregate by gender, ethnicity, race, home institution, etc. Thus, while the informant group in 2007–2016 was representative of the pool of participants based on high response rates, comparison of reported impact between demographic subsets for these data was not possible.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the data include responses from a small number of participants. This could make information individually identifiable. Requests to access the datasets should be directed to MP, exquiri.michael@gmail.com.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Texas A&M University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

## AUTHOR CONTRIBUTIONS

MP compiled applicable data from evaluation materials, completed the quantitative data analysis and secondary research, planned and led the group analysis of qualitative data, and drafted the manuscript. SM and JA coordinated the data gathering from partnering institutions, completed analysis of those data, helped to plan the presentation, and provided comments on drafts. KB-P, KW, SW, PO, FP, JM, and MR coordinated the site-specific activity, commented on plans for the manuscript, and gathered the data from PVAMU and TAMUCC. JK and HL planned and conducted the evaluation processes from which the data described were drawn. All authors contributed to the article and approved the submitted version.

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