frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 27 September 2024
DOI 10.3389/feduc.2024.1463923

OPEN ACCESS

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RECEIVED 12 July 2024
ACCEPTED 16 September 2024
PUBLISHED 27 September 2024

CITATION
Naik AR, Davidson CJ, Hurse DN and Kemp K (2024) A preliminary study of educational experiences that promote perceptions of college readiness in individuals from lower socioeconomic backgrounds interested in pursuing a career in science, technology, engineering, math, or medicine (STEMM).
Front. Educ. 9:1463923.
doi: 10.3389/feduc.2024.1463923

A preliminary study of educational experiences that promote perceptions of college readiness in individuals from lower socioeconomic backgrounds interested in pursuing a career in science, technology, engineering, math, or medicine (STEMM)

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Introduction: College readiness encompasses many different domains, including content knowledge, metacognitive skills, communication skills, learning strategies, and transitional knowledge. College readiness impacts academic achievement; moreover, student perceptions regarding college readiness impact their behavior and decision to attend college. High-achieving students from lower socioeconomic status (SES) areas possess grit and intelligence, but systemic barriers and inequities can interfere with the achievement of academic success in part due to reduced college readiness.

Methods: In this study, we explore if educational opportunities, such as outreach and pathway programs (OPP), Advanced Placement and International Baccalaureate, and college dual enrollment, impact perceptions of college readiness in a nationwide sample of 339 matriculating college students who wish to enter into Science, Technology, Engineering, Mathematics, and Medicine (STEMM) related fields.

Results: OPPs ($p = 0.005$) and dual enrollment ($p = 0.002$) are predictive of higher perceptions of college readiness. When individuals are partitioned into low and high SES by a median-split, OPPs ($p = 0.015$) and dual enrollment ($p < 0.001$) are predictive for students from low SES areas only.

Conclusion: This work indicates the importance of educational opportunities in improving perceptions of college readiness for students from low SES areas and potentially how resources may be better allocated in the future.

KEYWORDS

low socioeconomic status areas, STEMM outreach, pathway programs, dual enrollment, college readiness

1 Introduction

1.1 College readiness

College readiness is a crucial factor determining students' success in transitioning from high school to higher education. It includes academic preparation and the development of specific attributes essential for a college environment. College readiness refers to the level of preparation that high-school students should possess to meet college-level expectations, which are vital for matriculation into college and developing specific attributes that help them succeed (Conley, 2007). Traditionally, college readiness was measured through factors such as the percentage of students taking remedial classes in college, standardized test scores (e.g., ACT and SAT), or academic achievement during the first year of college (Conley, 2007). However, college readiness goes beyond content knowledge to encompass metacognitive skills, learning strategies, and transitional knowledge (Conley and French, 2014). Conley's definition of college readiness includes four components: Key Cognitive strategies (e.g., problem formulation, research, and communication), key content knowledge (structure of knowledge, attitudes toward learning, and technical knowledge and skills), key learning skills and techniques (ownership of learning and learning techniques), and key transition knowledge and skills (e.g., contextual, procedural, cultural) (Conley and French, 2014).

1.2 Impact of individual and area socioeconomics on educational attainment

Socioeconomic status (SES) significantly impacts educational experiences and outcomes (Levy, 2022). High family and neighborhood SES impact educational attainment (Conley and French, 2014; Nieuwenhuis and Xu, 2021). Those in high SES areas have access to resources that are not available to those in lower SES areas. Indeed, Martens et al. (2014) found living in public housing had a negative impact on health and education outcomes, but living in a high SES area when living in public housing was protective and helped mediate some of the effect. Moreover, a meta-analysis found educational outcomes are influenced by four neighborhood characteristics: neighborhood poverty, a poor educational climate, the proportion of ethnic/migrant groups, and social disorganization (Nieuwenhuis and Hooimeijer, 2016). The inequalities in accessing quality education are similar to the inequities in healthcare access, severely affecting academic progress, college readiness, and career opportunities for students from economically disadvantaged backgrounds (Ali et al., 2005; Aikens and Barbarin, 2008; Brown et al., 2016; Sanderson et al., 2021). There is a strong correlation between economic inequality and student achievement gaps in school districts across the United States (U.S.) (Hung et al., 2020). This economic inequality manifests in academic performance disparities and extends its influence on social capital, which is pivotal for college readiness. Social capital refers to the networks, relationships, and resources students can access via their family and community, which greatly help navigate the academic landscape and boost college preparedness (Hung et al., 2020).

Research on high-achieving students from economically disadvantaged backgrounds shows they have strength of will but also require agency or resources and support to achieve what they desire (Kundu, 2017). This is bolstered by findings that report what high-achieving secondary students living in low-SES areas perceive as being beneficial for their success. The two most prominent factors have been reported to be facilitating networks between students and mentors and creating a culture of hope in which students are seen as fully capable of succeeding (Williams et al., 2019). Students from economically disadvantaged families in higher education express feelings of not belonging, negative self-perceptions about their ability to succeed, and fear of failure. These factors serve as barriers to their success; however, opportunities that help them identify how their values are reflected in the educational space promote a sense of belonging within higher education, which is protective (Jury et al., 2017). Previous research has demonstrated a relationship between perceptions, intentions, and behaviors. Perceptions influence intentions to perform, as well as lead to beneficial behaviors (e.g., help-seeking, academic persistence, etc.) in higher education (Roland et al., 2018; Bornschlegl et al., 2021) that will make it more likely that the student will succeed (Ellis and Helaire, 2023). In addition, self-efficacy, the belief of an individual in their ability to achieve, positively affects academic success in college and beyond (Honicke and Broadbent, 2016; Hayat et al., 2020).

1.3 Educational experiences that promote college success and entry into STEMM fields

Educational experiences, particularly positive ones, can increase interest in STEMM fields. Moreover, these experiences can cultivate skills needed for college success. Advanced offerings such as advanced placement (AP), international baccalaureate (IB), and dual enrollment courses (where high school students are enrolled in college or university courses) are promoted by school districts across the US and are utilized by students to signify their readiness for college. AP and IB courses take place in a high school setting, are taught by high school teachers, and provide rigorous coursework that requires the application of critical thinking and analytical skills and develops a deeper understanding of fundamental concepts. AP courses typically occur over a year and multiple courses can be taken at a time, while IB is a rigorous program composed of six core classes, takes place over 2 years, and is recognized internationally. Students must take an IB examination to receive an IB diploma. Like in IB programs, students who take AP can opt to take an end-of-course examination. Those who take and pass their individual content IB and AP course examinations may be awarded college credit contingent on the policies of the college or university. Students who participate in these programs achieve similar graduation success at college (Schumacker, 2014). In contrast, dual enrollment may occur at a college or university setting alongside adult learners, online, or be taught in a high school setting by teachers who are also adjunct faculty. Successful completion results in postsecondary credit.

Students who participate in these advanced offerings often enroll in college (Speroni, 2011); however, there is some debate over whether

Abbreviations: SES, Socio-economic status; OPP, Outreach and Pathway Programs; STEMM, Science, Technology, Engineering, Mathematics, and Medical; URM, Underrepresented minorities; U.S., United States.

or not these programs themselves promote college success. There are conflicting results from studies, with many studies set at a particular college or region of the US. This has the potential to introduce other variables that can impact results. However, an analysis performed by the Institute of Education Sciences over five studies found dual enrollment increased high school attendance and graduation and college degree attainment (Works Clearinghouse, 2017). There were also positive effects on college readiness; however, there was no impact on academic achievement in college (*ibid*). Moreover, those who were dual-enrolled in a 4-year college were more likely to matriculate than those who were not dual-enrolled (Wyatt et al., 2015), and dual enrollment was shown to promote college readiness (An, 2013). These studies are supported by work from the National Center of Postsecondary Research that explored the impact of AP and dual enrollment on Florida graduates. They find that AP and dual enrollment both promote college enrollment and bachelor's degree attainment; however, location mattered, as those who took dual enrollment courses at their high school did not have increased college enrollment or bachelor's degree attainment. In addition, students who participated in dual enrollment were more likely to attend college directly after high school, while students who participated in AP were more likely to enroll in a four-year college, but both groups had similar levels of bachelor's degree attainment (Speroni, 2011). In contrast, Klopfenstein and Thomas found that AP experiences did not promote first-semester grades or retention (Klopfenstein and Thomas, 2009). Moreover, merely taking AP courses does not impact ACT/SAT scores or matriculation into college (Conger et al., 2023). However, students who take and pass the AP exam obtain a higher ACT score (Warne et al., 2015). Similarly, studies exploring the impact of IB programs have found that their outcomes are comparable. A single-site study exploring the impact of IB on honors college students found no difference in GPA when controlling for gender or minority status; however, completion of four or more courses led to greater persistence, and qualitative data suggested that IB students were more prepared to adjust to the rigors and expectations of college (Conley et al., 2014).

External educational experiences may also promote college readiness. Outreach and pathway programs (OPP) offer numerous benefits, including the important factor of fostering partnerships between K-12 educators, students, communities, and higher education institutions to enhance educational opportunities for children and adolescents from all economic backgrounds (Muijs et al., 2004). Furthermore, they promote self-confidence and increase student retention rates in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) (Rocha et al., 2022a, 2022b). Due to how these programs are structured, many OPPs are positioned to enhance equity and inclusion in STEMM by improving postsecondary education preparation through mentorship and the creation of networks. Ideally, OPPs will build skills that foster success and create a culturally responsive learning environment where diverse individuals can learn and work collaboratively. Despite the recognized benefits of OPPs, there is a need for more comprehensive studies to examine their impact on students' perceptions of college readiness, especially those interested in STEMM fields.

This study aims to explore the relationship between the perception of college readiness and educational experiences among high school graduates during their first semester of college. The educational experiences are OPPs, dual enrollment, and AP/IB. We also explore the relationship between demographic factors such as race and ethnicity, first-generation college status, household income bracket, and community SES on perceptions of college readiness.

Our research adopts an equity-oriented framework, concentrating on the equitable distribution of resources and opportunities through educational experiences. In this preliminary study, we investigate if OPPs, dual enrollment, and AP/IB participation can level the playing field for students from lower-income backgrounds regarding their perception of readiness for college. The goal is to provide actionable insights for K-12 educators, higher education institutions, and communities, enabling them to foster inclusive practices that ensure equal educational opportunities for all students, irrespective of socioeconomic status.

2 Methods

2.1 IRB approval

The Oakland University Institutional Review Board approved this study in August of 2022 (Protocol # 2022–346). All participants were informed of confidentiality and gave informed consent before participating in the study.

2.2 Equity-based research framework

The project followed an equity-based research framework, as proposed by Venkateswaran et al. (2023). The research team is composed of individuals with differing experiences concerning immigration status, race and ethnicity, religion, ability status, socioeconomic, and expertise that acknowledge that worldviews and experiences have the potential to impact work. To combat this, the team continuously reflects on how their experiences may impact the work. It centers this work on examining how the assets and aspirations of students can counter socioeconomic factors that can negatively impact access. Our work is focused on highlighting the fact that while students may have aspirations to succeed in STEMM-related fields, there are significant disparities in college-related outcomes such as enrollment, retention, and graduation rates, particularly for students from lower socioeconomic status (SES) backgrounds. The research highlights the importance of OPPs and dual enrollment in potentially reducing the differences in college readiness and success, thus promoting educational fairness for all students who aspire to pursue STEMM-related fields.

2.3 Participant recruitment

Three hundred and sixty-five individuals who recently graduated from high school and had newly matriculated into college were recruited via word of mouth and through Centiment LLC's data collection platform between 09/2022 and 11/2022. Individuals were from 40 US states and Washington D.C based on the 316 unique ZIP Codes reported out of 330 confirmed ZIP Codes (95.75% unique codes; Figure 1). Individuals with an interest in in healthcare, biomed, medicine, or physical/chemical/biological science occupational fields were recruited regardless of their educational experiences prior to college. An effort was made to limit white only, non-Hispanic

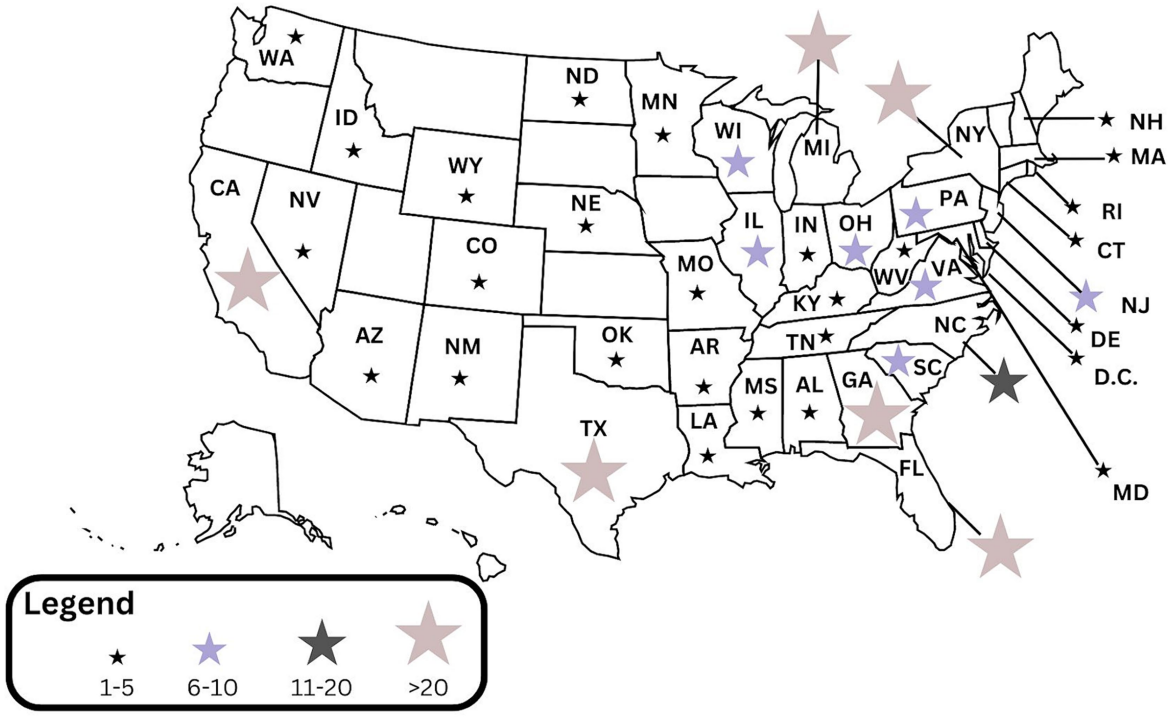

FIGURE 1
Location of participants across the US. The reported ZIP codes were used to map participant locations.

participants at 60% to match current U.S. demographic data based on the 2020 Census which reports the U.S. white, non-Hispanic population is 57.8% (Jensen et al., 2021). Participant data was collected anonymously and stored according to the approved IRB protocol.

2.4 Measures

This research was accomplished using a survey designed to focus on quantitative measures about participation in OPP experiences and perceived readiness for college education in STEMM-related domains. Beyond the focus on quantitative measures, a few qualitative questions were included to allow for open-ended responses and further contextualize the responses seen in the quantitative measures. This design is beneficial for multiple reasons, including (1) ease of administration and data collection, (2) sampling from a nationwide sample, (3) incorporating a diverse array of SES demographics, and (4) the use of quantitative statistical analysis techniques.

2.4.1 Survey questions

Three hundred and thirty-nine individuals completed the survey and thus met the criteria for inclusion. Demographic information gathered from participants can be found in Table 1. Specific components of demographic information included race and ethnicity, gender, age, estimated household income, number of individuals within the household, participation in advanced placement/international baccalaureate, participation in dual enrollment programs, first-generation college status, ZIP Code, and age. For the purposes of this analysis, individuals who self-selected Black/African American, Pacific Islander, Hispanic, and Native American were considered as underrepresented minorities (URM) according to the National Science Foundation definition (National Science Foundation, 2023). In this study, both AP and IB programs were considered as a single group for analysis due to the programs occurring in a high school setting, being taught by high school teachers, and similarities in student populations, outcomes, and requirements for students to achieve a certain score to qualify for college credit or being allowed to pass out of a college course.

The survey (see Supplemental material) was composed of questions regarding the types of OPP experiences that they have had, what they learned from these OPP experiences, and their self-perception of college readiness. Individuals were asked if they felt prepared for college (binary response yes/no). The specific items assessing OPP experiences are shown below and were coded as binary (yes/no), resulting in an overall total of 0 to 4 experiences:

1 Have you ever participated in a program or outreach activity geared at recruiting young adults, adolescents, or children into the science, engineering, technology, math, or medical fields?
2 Have you ever participated in science fairs outside of those that may have been required for school?
3 Have you ever participated in Math Olympics, Science Olympics, robotic clubs or competitions, or any other science, tech, engineering, math, or health-related educational competition?
4 Have you ever participated in an after-school, before-school, weekend, or holiday/summer break science, tech, engineering, math, or health-related program class or camp?

TABLE 1 Demographics of the individuals enrolled in the study population.

Gender*	Percentage	Count
Female	54.3%	184
Male	43.1%	146
Non-binary	2.4%	8
Prefer not to respond	0.3%	1
Race/Ethnicity**		
AA/Black	33.6%	114
Asian	6.2%	21
Hispanic (any race)	28.6%	96
Native American	2.9%	10
Pacific Islander	0.6%	2
White	39.2%	133
Multi-racial	5%	19
Other	9.4%	32
Prefer not to respond	2.7%	9
Income		
<25,000	24.0%	81
25,000-49,999	30.4%	103
50,000-74,999	17.1%	58
75,000-99,999	13.0%	44
100,000 or more	11.5%	39
Prefer not to answer	4.1%	14
1st generation college student		
Yes	56.0%	190
No	43.7%	148
No answer	0.30%	1
Advanced placement/International baccalaureate		
Yes	58.1%	197
No	41.9%	142
Dual enrollment		
Yes	59.9%	203
No	40.1%	136

*One participant selected both male and non-binary.
** Individuals were allowed to select multiple fields. 5% of respondents are bi/multiracial:0.6% Asian and Native American, 1.2% African American and White, 1.2% Asian and White, 0.3% Native American and White, 0.6% African American and Asian, 0.9% Native American and African American, 0.3% Asian and Pacific Islander, and 0.3% African American, Native American, and White.

We utilized correlation and logistic regression analyses to identify experiences that impact perceptions of preparedness for individuals from both low and high-SES areas. We also identified and mapped out the skills, knowledge, and behaviors learned from participation in OPPs that promote college readiness based on Conley's four principles of college readiness (Conley and French, 2014).

2.4.2 Coding free responses

Free responses were coded based on Conley's four principles of college readiness and knowledge needed for their future career path and academic self-efficacy using the deductive qualitative framework (Gale et al., 2013). Responses that did not map to Conley's four principles were coded under "other." Two individuals coded the responses separately. The initial rate of agreement was 94.2%. A third reviewer resolved any disagreements.

2.5 Data analysis

2.5.1 Community SES calculation

We calculated the SES scores for the community that the participants lived in during high school based on U.S. census data as in a previous publication (Hurse et al., 2023). Briefly, the ZCTA5 codes for the reported ZIP Codes were determined using the free, publicly available UDS Mapper tool, funded by the Health Resources and Services Administration, Bureau of Primary Health Care, and coordinated by the Robert Graham Center (https://geocarenavigator.hrsa.gov/). Two members of the team utilized the US Census website and the ZCTA5 codes to extract reported data for owner-occupied housing, median home values, percent in the workplace, *per capita*, and percent bachelors from the following tables DP03, DP04, S0601 (2021 ACS 5-year estimates data profiles; https://www.census.gov/). The data was normalized using values from the state from which the ZCTA5 code originated in part because of the variability across the US states regarding socioeconomic factors. The normalized values were then summed as previously reported (Hurse et al., 2023). The ZCTA5 codes and US Census data were extracted between December 2022 and August 2023 by two members of the team. Two additional key personnel reviewed the extracted data for accuracy. When discrepancies were flagged, a team member reviewed the data tables to confirm that there was a discrepancy and the error was corrected. Individual's scores were normalized to their state SES metrics, arranged in ascending order, and partitioned into low or high SES groups (based on a median-split procedure; median-4.427, IQR-5.570-3.642) to aid in the exploration of this data and make the conclusions more generalizable across states. Nine individuals failed to provide a valid ZIP Code and were not included in the analysis involving this variable.

2.5.2 Statistical analysis

These data were analyzed using SPSS version 29 software, and due to this being a preliminary investigation, an uncorrected threshold p-value of ≤ 0.05 was used to determine statistical significance. Pearson correlations were run between the perception of college readiness (also called "college readiness") and the following variables: the number of OPP experiences, participation in AP/IB, participation in dual enrollment programs, race, ethnicity, income, and first-generation status. This was done to determine the strength and direction of the association, allowing us to identify relevant variables for our model. Multiple logistic regressions were run between the independent variables the number of OPP experiences, AP/IB, and dual enrollment, and the dependent variable perception of college readiness (also referred to as college readiness). Multiple logistic regressions were also run between the type of OPP experiences (independent variables) and college readiness as the dependent variable. We did not compare the types of experiences, as this was not the focus or intention of the investigation, and individual programs may vary in terms of their quality. After a median split procedure, bifurcating the sample by SES status into low and high, separate multiple logistic regressions were conducted as defined above. The independent variables were (1) Number of OPP experiences, (2) AP/IB, (3) Dual Enrollment, and the dependent variable percep0on of college readiness.

2.6 Figures

All figures were created using the online website Canva.

3 Results

3.1 Participation in OPPs or dual enrollment predicts perceptions of college readiness

The collection method resulted in a sample that is predominantly White/European, African American/Black, and majority female. African-American/Black individuals are overrepresented in the sample (33.6% vs. 13.3% U.S.), and White/European individuals are under-sampled (39.2% vs. 50.5% U.S.). Twenty-eight percent of individuals identified as Hispanic of any race (see Table 1). Approximately 84% of the students in our survey responded that they felt prepared for college. Race, ethnicity, income, or first-generation status did not correlate with perceptions of college readiness (Supplementary Table S2). However, participation in educational experiences beyond those required for graduation from high school did correlate with feeling prepared for college (AP/IB, dual enrollment, or OPPs; Supplementary Table S1). Interestingly, participation in OPPs ($p = 0.005$) and dual enrollment predicted perceptions of college readiness ($p = 0.002$), but AP/IB did not ($p = 0.763$; Table 2). Further analysis found participation in STEMM program classes and camps outside of school drives the model ($p = 0.003$; Table 3). Individuals were split into low SES and high neighborhood SES groups based on the median, and a multiple logistic regression accounting for neighborhood SES was performed. We found the model was significant only for individuals that were from low neighborhood SES areas regarding dual enrollment ($p < 0.001$) and OPP participation ($p = 0.015$; Table 4).

3.2 Students identify gains in skills that relate to college readiness and academic self-efficacy due to their OPP experiences

While previous work has shown dual enrollment increased perceptions of college readiness (An, 2013), little is known about the impact of OPP experiences on this measure. Therefore, we focused our qualitative analysis on addressing this deficit. Two hundred and seventy-nine participants reported having at least one OPP experience, with 217 (78%) stating that they obtained at least one skill due to the experience. The majority of these individuals responded when allowed to elaborate on the skills they learned through OPP experiences 85% ($N = 185$). Two Hundred and six skills were extracted from these 185 open-ended responses. They were then mapped to Conley's principles of college readiness or "other" if they did not fit the predefined categories. Twenty percent of comments were coded to cognitive strategies, 28% to content knowledge, 23% to learning skills/techniques, and 4% to transition knowledge. Another 24% of comments were coded as "other." Examples of the comments can be found in Figure 2.

TABLE 2 Perception of readiness increases with more OPP experiences or dual enrollment.

	B	df	X^2	*p* value	Odds
Number of OPP experiences	0.381	1	7.823	0.005**	1.464
Dual enrolled	1.087	1	9.880	0.002**	2.965
AP/IB	0.99	1	0.91	0.763	1.105

Multiple logistic regressions were run.*Individuals were divided into groups by the number of OPP experiences (0, 1, 2, 3, and 4). Dual enrollment and AP/IB are binary choices. The dependent variable is the perception of college readiness and the independent variables are the number of OPP experiences, dual enrollment, and AP/IB.

TABLE 3 Participation in STEMM classes and camps is driving the OPP and readiness model.

Have you ever participated in…	*B*	df	X^2	*p* value	Odds
STEMM program or outreach recruitment activity?	0.597	1	3.256	0.071	1.817
External science fairs?	0.305	1	0.779	0.377	1.356
STEMM educational competition?	0.138	1	0.158	0.691	1.148
STEMM program class or camp outside of school?	1.025	1	8.987	0.003**	2.786

Multiple logistic regressions were run. The dependent variable is the perception of college readiness. The independent variables are shown in the leftmost column.

TABLE 4 OPPs and dual enrolment participation impacts students from low SES areas more than those from high SES areas.

		B 95% CI [Lower, Upper]	Beta	*p* value
Low SES				
	Constant	0.776 [0.585, 0.967]		<0.001
	Number of OPP	0.056 [0.011, 0.101]	0.201	0.015*
	Dual enrollment	0.230 [0.106, 0.355]	0.304	<0.001**
	AP/IB	−0.033 [−0.148, 0.082]	−0.045	0.570
High SES				
	Constant	0.904 [0.700, 1.108]		<0.001
	Number of OPP	0.038 [−0.009, 0.086]	0.139	0.115
	Dual enrollment	0.062 [−0.061, 0.185]	0.083	0.320
	AP/IB	0.069 [−0.056, 0.195]	0.092	0.278

A multiple logistic regression was run using median SES split. *Individuals were divided into groups by the number of OPP experience types (0, 1, 2, 3, and 4). Dual enrollment and AP/IB are binary choices. The dependent variable is the perception of college readiness and the independent variables are number of OPP experiences, dual enrollment, and AP/IB.

FIGURE 2
Comments from participants regarding what they learned from OPP participation. Individuals were given the opportunity to elaborate on the skills they learned. Examples of those that map to Conley's college readiness are above.

4 Discussion

4.1 Impact of educational experiences on college readiness

The main goal of our study was to explore what educational experiences influence the perception of college readiness amongst matriculating students pursuing a career in STEMM. Approximately 84% of the students in our survey responded that they felt prepared for college. Further analysis shows that participation in educational opportunities, like dual enrollment, AP/IB programs, and OPPs, correlates with perceptions of college readiness (Supplementary Table S1). When we explored these relationships by conducting a regression analysis, we found that OPPs and dual enrollment participation significantly predicted the perception of college readiness. Indeed, when participants were allowed to elaborate on skills gained from participation in OPPs, 76% of skills could be mapped to Conley's principles of college readiness. Further analysis finds the OPP and readiness model is driven by participation in classes and camps outside of school. However, when this data was separated based on SES (median split procedure), dual enrollment and OPP participation predicted perceptions of college readiness only for students from low SES areas ($p < 0.001$ and $p = 0.015$, respectively). Income, race, ethnicity, and first-generation status, differing from some previous investigations, did not correlate with perceptions of college readiness. It is important to note that while household income factors into SES, it is not the sole defining factor. Moreover, neighborhood factors such as the SES of an area, the quality of schools, and the norms and expectations of the community all play a role in achievement (Moore et al., 2007; Nieuwenhuis and Xu, 2021; Levy, 2022). Similar to our findings, a study by Cannady et al. (2017) found that income, race, ethnicity, and first-generation status factors did not predict whether individuals entered a high-skilled STEMM career vs. a high-skill non-STEMM career. However, they found taking an advanced math course, taking an advanced science course, expecting to go into a science or engineering career, and factors like being male or having married parents all were significant predictors of entry into a high-skill STEMM career (Cannady et al., 2017).

An earlier study found dual enrollment predicted college GPA and reduced the likelihood of remediation in students with lower SES (An, 2013). This may be because dual enrollment bolsters Conley's key components of college readiness. Conley's principles of college readiness are built upon four components: key cognitive strategies, key content knowledge, learning skills and techniques, and transition knowledge and skills (Conley and French, 2014). Possessing each of these four components of college readiness is important to succeed in college. While the components "key content knowledge" and "transition knowledge and skills" can be classified as technical information needed to be successful in college, it is the softer skills, such as key "cognitive strategies" and "learning skills and techniques," that are required to skillfully manage and sift through information that suit one's own learning needs. OPPs have been reported to increase a sense of belonging, self-efficacy, and content knowledge (Jury et al., 2017; Kuchynka et al., 2022), all of which may contribute to Conley's four components of college readiness. Figure 3 illustrates the relationship between external educational opportunities, college readiness, and perceptions of preparedness for college.

Students from low-income backgrounds who demonstrate high levels of achievement possess grit (Kundu, 2017). Grit refers to the ability to persevere and stay focused despite significant obstacles. It is

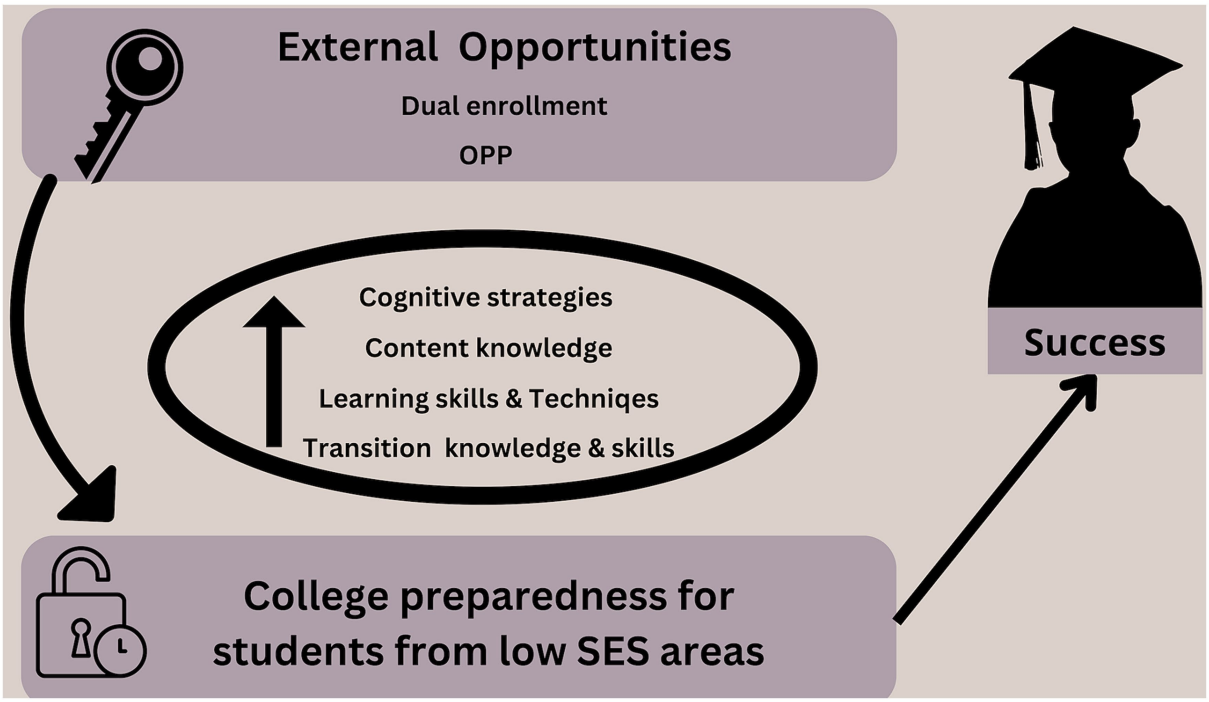

FIGURE 3
External opportunities improve perceptions of college preparedness. External opportunities improve perceptions of college preparedness of students matriculating from low SES areas by increasing the four key components of college readiness as explained by Conley. This in turn leads to success and achievement in college.

related to determination, resilience, self-discipline, and focus in pursuit of long-term goals within the field of education (Bashant, 2014). All of these are aspects that any student must maintain; however, they are of particular importance for STEMM-focused students. Grit, perseverance, and resilience are better indicators of success in college than GPA and SAT scores (Duckworth et al., 2007), with grit promoting college success and academic achievement (Reysen et al., 2019). However, "agency" is very important when assessing academic achievements. Research shows three emerging themes: mental health, networking, and goal formation, as beneficial for the success of students from low SES backgrounds (Kundu, 2017). While individuals from low SES areas may have grit, they do not always have agency, and both are needed to navigate and succeed in STEMM-focused programs and fields.

The rise of social media and improved internet connectivity has brought about a significant change in how students access college-related information. This is particularly beneficial for those who have limited familial experience with college (e.g., first-generation students). Social media platforms have boosted students' confidence in their ability to apply to and succeed in college, in addition to enhancing their networks and providing valuable collegiate insights (Wohn et al., 2013). Social media use can enrich transitional knowledge, agency, and critical learning skills necessary for self-efficacy and persistence in education, with notable benefits for Black students in urban areas (Brown et al., 2022). While social media platforms offer a wealth of information, students may need help interpreting and utilizing this knowledge fully and effectively (Brown et al., 2016). This is where external educational opportunities can play an important role. These programs and resources act as a vital scaffold, providing students with the necessary framework to understand, integrate, and apply the information gleaned from social media. Moreover, these educational opportunities bridge the gap between information access and comprehension by offering structured learning environments, mentorship, and tailored guidance. They play a pivotal role in translating complex online information into actionable knowledge, thereby enhancing students' transitional skills and reinforcing self-efficacy in the educational realm. In essence, external educational opportunities are vital in translating the potential of digital platforms into tangible educational success. Furthermore, external educational opportunities, like dual enrollment and OPP programs, help reduce disparities. Lane et al. found that a STEMM intervention program that targeted underrepresented students attending college enhanced college readiness as defined by Conley (Lane et al., 2020). We surmise that they fulfill the two most prominent factors: (1) creating networks between students and mentors and (2) building a culture of hope in which students are seen as fully capable of succeeding (Williams et al., 2019).

4.2 Why dual enrollment improves perceptions of college readiness

Currently, students seeking to gain exposure to college-level courses take AP courses, attend IB programs, or engage in dual enrollment. Of these options, dual enrollment has been shown to promote matriculation and retention rates. Moreover, those who were dual-enrolled in a 4-year college were more likely to matriculate than those who were not dual-enrolled (Wyatt et al., 2015). This may

be related in part to an increased perception of readiness. As with a previous study (An, 2013), we found dual enrollment increased perceptions of college readiness among our STEMM-focused students. Indeed, they also found those dual enrolled had statistically more characteristics associated with Conley's Concepts of College Readiness compared to those who received college credit before enrollment and were not dual enrolled. We did not find evidence that AP and IB participation predicted the perception of college readiness in our model. We speculate this is because students can take these courses but fail the exam or elect not to take the exam. Moreover, any student who answered that they took AP/IB courses was included, regardless of the number of courses taken or passed. Interestingly, the majority of our respondents indicated passing their AP/IB exams. We did not account for the number of courses taken and exams passed. Future studies will need to explore the quantity and quality of AP/IB courses as an important factor in influencing perceptions of college readiness.

While participation in dual enrollment and accelerated courses is beneficial, access is not equitable (Taylor et al., 2022). Davis et al. found individuals enrolled in accelerated courses in Minnesota were more likely to be high-income, white, and female (Davis et al., 2017). Haskell et al. found that the enrollment of low-income and underrepresented minorities (URM) students in dual enrollment and early college high school programs in Utah was significantly lower than that of traditional school enrollment (Haskell and Gore, 2016). This was similar to findings by Miller et al. (2017) survey of dual credit enrollment within Texas (Miller et al., 2017). This highlights that while dual enrollment can increase access to college courses, especially for those in low SES and rural areas, states must prioritize promoting its availability and benefits to increase equity.

4.3 Why OPPs improve perceptions of college readiness

OPPs present a great opportunity to develop skills associated with college readiness. Positive experiences in OPPs increase the likelihood of attending college (Zhou, 2020). Previous work shows that OPPs, in addition to improving content knowledge, have a positive impact on high school graduation rates, promote understanding of college culture, increase networking opportunities, provide a sense of belonging, and provide behavioral and psychosocial support (Domina, 2009; DuBois et al., 2011; Jung et al., 2023). Indeed, we found that individuals in the current study were able to identify skills associated with all aspects of Conley's college readiness. Moreover, they were able to identify other skills, such as leadership and social skills, as having improved/developed due to program participation. Although the majority of individuals who participated in OPPs said they learned skills, approximately one in five students (22%) stated that they did not. We speculate that this is in part due to OPPs varying in program structure, content, and quality. To address these components, it is important that programs include diverse leadership, consider the cultural background of participants, and utilize student-centered design (Crews et al., 2020; Luecke et al., 2023). Mentorship and networking opportunities are invaluable, and these components should be better incorporated into the program design. This is particularly important if the goal is to increase retention of URM, women, and individuals from lower socioeconomic backgrounds in STEMM, as these prove beneficial (Dennehy and Dasgupta, 2017; Daniels et al., 2019; Jung et al., 2023; Kaggwa et al., 2023).

5 Limitations and future directions

Although our study offers valuable insights, it has some limitations. We were unable to thoroughly evaluate the structure, components, and quality of the educational opportunities in which the participants took part. Because of the inherent variability among instructors and course designs across the United States, future research should strive to incorporate validated metrics or assessments of student perceptions regarding these course elements to ensure a more nuanced understanding of their impact.

In the absence of a theoretical justification, our analysis did not factor in the relative importance of the four components of OPPs in influencing student perceptions of readiness. However, our findings suggest a notable correlation between components related to extracurricular engagement (STEMM camps and classes outside regular school hours) and increased perceptions of readiness. Future studies could benefit from integrating these insights, employing a stepwise regression approach emphasizing these significant factors first. It is noteworthy that these factors appear particularly salient for participants from lower SES areas. Additionally, a more nuanced outcome may be found with a scaled as opposed to binary representation of perceptions of readiness.

Calculating SES based solely on students' ZIP Codes has limitations. This approach oversimplifies the complex nature of communities. Future research should consider a more comprehensive approach, such as focusing on the SES of the school, parents, and students or a weighted combination of these factors. Personal drive and interest, knowledge, preparation, teacher qualifications, access and opportunity, and perception of ability all play a role in overall academic success (Kerr et al., 2018; Chen et al., 2020). While ZIP Code data is useful, it may only partially capture the nuanced economic and social environments students experience. ZIP Codes can encompass diverse populations with varying access to resources, and economic conditions within a single ZIP Code can be quite diverse. The median-split procedure was justified in this context to simplify the analysis and allow for more straightforward comparisons between groups. However, it may still obscure the gradient of SES effects.

While a positive relationship exists between perceptions of college readiness and OPPs or dual enrollment for those interested in STEMM associate fields, it is possible that this is only true for those entering college. We did not explore how OPPs and dual enrollment impact individuals that matriculate into trade programs or go directly into the work force. This would be of interest for future studies. Moreover, it is possible that the relationship between perceptions of college readiness and OPPs and dual enrollment are not causal. However, the qualitative data analysis presented in this study, and a previous study exploring the impact of dual enrollment and its impact on college readiness (An, 2013) provide evidence that dual enrollment and OPP experiences promote college readiness. This leads us to conclude that causal relationship is unlikely.

Lastly, our study primarily focused on the perceptions of readiness without directly measuring subsequent academic

success. While perceptions are critical in shaping behavior, their alignment with actual performance remains uncertain. Thus, future research must measure both perceived readiness and actual performance outcomes to fully understand this dynamic, possibly in a longitudinal design that tracks students through college completion.

Despite these limitations, we remain confident in the robustness and quality of our design, data, analysis, and conclusions. This study lays a foundation for further exploration and deepens the understanding of educational preparedness, catalyzing more comprehensive future research in this field.

6 Conclusion

Our research delves into the crucial topic of college readiness, explicitly focusing on how OPPs and dual enrollment improve perceptions of college readiness in matriculating college students, particularly those hailing from low SES areas. Our study illuminates the multifaceted influences on college readiness, which in this study is described as extending beyond traditional academic measures to include factors like self-efficacy, social capital, and the development of metacognitive learning strategies and transitional skills.

Our core finding is a strong positive relationship between participation in OPPs and dual enrollment programs and the perception of college readiness among students from lower SES backgrounds. This readiness is not just an academic preparation but a holistic development encompassing cognitive strategies, content knowledge, learning techniques, and transitional knowledge as outlined by Conley (see Figure 3). Our research underscores the vital role of extracurricular engagement, in enhancing students' readiness perceptions. This insight is essential, considering that traditional metrics often overlook these critical components of preparedness.

By adopting an equity-oriented framework, our research contributes significantly to understanding educational inequalities and the mechanisms that can alleviate them. It emphasizes the importance of inclusive educational practices and the provision of diverse opportunities for students from all backgrounds. Our study also adds to the body of literature, highlighting the need for a broader perspective on college readiness that transcends conventional academic benchmarks.

In conclusion, our research reaffirms the multifaceted nature of the perception of college readiness and emphasizes the need for equitable access to educational resources. By bridging the gap between perception and reality in college readiness, we pave the way for a more inclusive and effective educational landscape. Our study serves as a call to action for continued exploration and implementation of strategies that foster a supportive and enriching educational environment for all students, regardless of their socioeconomic status.

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 humans were approved by the Oakland University IRB, Protocol # 2022–346. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. CD: Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. DH: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. KK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. We want to thank the Oakland University Black Faculty Association for funding this work.

Acknowledgments

We would like to acknowledge the OU, and OUWB for resources and time to work on this project as well as the OU Writing Center for their help in editing this work. We also want to thank Samuel and Sarah John for their help confirming the extracted data and checking for errors.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1463923/full#supplementary-material

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