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Small course interventions focused on whole-person development increase aspects of student affect for women, Asian and first-generation students

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Students from historically excluded groups are more likely to persist in STEM if they believe that what they learn can provide them with tools to better their communities. One way to achieve this is to contextualize course content in ways that empower students to develop positive identities with science. Given the disproportionate ostracism of persons excluded based on ethnicity or race (PEERs) from STEM degree programs, we examined student responses to incorporating modules that emphasized either the relevance of course content or whole-person development into discussion sections of a large-enrollment introductory environmental sciences course. Reflection activities in the relevance sections emphasized how the course content related to societal problems of interest, while reflection activities in the whole-person development sections focused on how to use college and career to live a fulfilled, productive life. To measure the impact of these different reflection modules, we administered pre–/post-surveys with questions that queried life satisfaction, science motivation, sense of belonging, and expectations for college. Results demonstrate that women, Asian students, and students with neither parent attending college demonstrated significant increases in specific aspects of student affect like personal science motivation, life satisfaction and/or sense of belonging regardless of intervention type. Small psycho-social interventions like these can be added to existing course structures to improve student affect and potentially serve as a steppingstone to bigger course reforms.

KEYWORDS

stem, utility-value, holistic development, historically excluded groups, intervention

Introduction

Addressing global challenges such as climate change, infectious disease management, and sustainable energy production, to name a few, requires STEM professionals who can work collaboratively and apply what they know to solve complex problems. Producing competent STEM graduates that represent diverse backgrounds is vital to meeting workforce needs as well as addressing systemic inequities in STEM-related careers. As a result of systemic inequities in higher education, persistence in STEM by students from historically excluded groups (HEGs) is still a troubling issue in higher education. Less than half of all students entering college in the U.S. intending to major in STEM persist in STEM until graduation (PCAST, 2012). Studies show

that these exit rates are even higher for historically excluded populations of students. For example, 43% of White students who intended to major in STEM eventually received a STEM degree, while only 22% of Black students and 29% of Latine students graduated with STEM degrees (Eagan et al., 2014). This is despite the fact that Black and Latine students are just as likely to enter STEM majors as their White peers (Garrison, 2013; Riegle-Crumb et al., 2019). Attrition from STEM degree programs, particularly in the first 2 years, is a complex issue with many contributors such as heavy course loads, passive teaching strategies, diminished student confidence, sense of belonging, and lack of encouragement to pursue professional careers in the sciences (Seymour and Hewitt, 1997; Freeman et al., 2007; Chang et al., 2008; Alexander et al., 2009; Haak et al., 2011; Chen, 2013; Dika and D'Amico, 2016; Eddy and Brownell, 2016; Lewis et al., 2016; Theobald et al., 2020; Whitcomb and Singh, 2021).

While the causes are systemic, a deficit mindset lays the blame for these disparities in persistence or performance on students, e.g., their personal or cultural characteristics, and ignores or misses the systemic inequities at the root of the problem (Patton Davis and Museus, 2019). The disproportionate exclusion of HEGs demonstrates the deeply problematic culture of White supremacy that exists within higher education which further extends to a culture of cis heteropatriarchy in STEM majors that discriminates against students on the basis of gender or sexual identity (Miller et al., 2021). Studies have demonstrated that these identity stereotypes have negative impacts on non-White or non-cisgender men in the form of decreased sense of belonging and motivation to pursue STEM majors or study science, highlighting the importance of building community and sense of place for students in college (Harackiewicz et al., 2014; Brown et al., 2015a; Casad and Bryant, 2016; Lewis et al., 2016; Master et al., 2016; Master and Meltzoff, 2020). In addition, the isolating environment of STEM disciplines drives away students, particularly women and those from HEGs, because it does not support their goals of collaboration and helping others (Duffy and Sedlacek, 2007; Cheryan et al., 2009; Diekman et al., 2010; Weisgram et al., 2010). This mismatch in personal goals and representations of what a particular career or field offers in terms of communion is referred to as communal goal incongruity (Diekman et al., 2010). Perceptions that STEM careers lack communal affordance exacerbate the exclusion of women from the sciences (Diekman et al., 2010; Boucher et al., 2017). The success and persistence of women in STEM is positively correlated with perceived identity compatibility, and perceived support from others (Rosenthal et al., 2011). In looking at identity compatibility and social roles, women attribute more importance to benevolence than do men (Schwartz and Rubel, 2005). Gender differences have been shown to exist primarily on communal rather than agentic goals, with goal affordance stereotypes reflecting beliefs that STEM careers do not fall in line with communal goals (Diekman et al., 2011). Research shows that these gender differences can significantly affect the choice to pursue STEM related studies and careers, as well as overall performance in STEM (Halpern et al., 2007). The potential for a STEM career to afford communal goals elicits greater positivity and career interest in students within science (Diekman et al., 2011; Brown et al., 2015b).

In 2020, the National Academy of Science, Engineering and Medicine (NASEM) ran an ideas competition to elicit responses to the prompt, "What should STEM education look like in 2040?." The top entries became the basis for a virtual symposium in 2021, Imagining the Future of Undergraduate STEM Education, that highlighted inspiring full-course or curriculum-wide transformations that replaced traditional lecture courses with scaffolded apprenticeship-like experiences where students applied their knowledge while contributing solutions to challenging societal issues. Hallmarks of these high impact teaching practices are their active, collaborative nature and opportunity for students to apply their learning to authentic, real-world issues which are of importance outside the classroom (Kuh, 2012). For example, activities, even relatively small ones, that allow students to see the personal relevance of course material, called utility-value interventions, have been shown to successfully reduce the achievement gap for first generation and historically excluded students (Harackiewicz et al., 2016). In one study, historically excluded students serving as research assistants who saw the altruistic value of conducting biomedical research felt more psychologically involved with their research over time, enhancing their interest in pursuing a scientific research career (Thoman et al., 2015). Replacing lecture courses with high impact practices like these can improve equity within the classroom, student motivation, performance, and persistence (Lopatto, 2007; Hanauer et al., 2012; Bangera and Brownell, 2014; Kilgo et al., 2015; Rodenbusch et al., 2016; Collins et al., 2017; Shuster et al., 2019).

While these examples offer hope and aspirational targets, most post-secondary STEM educators still do not use active, student-centered practices (Stains et al., 2018) despite decades of literature and reports recommending them. Changing faculty behavior is often difficult (Henderson et al., 2012). There are many barriers, including lack of time, incentive, and training and fear of student resistance, that contribute to this persistence of teaching strategies that fail to support student learning and persistence (Pundak and Rozner, 2008; Brownell and Tanner, 2012; Anderson et al., 2019; Bathgate et al., 2019). As a potential steppingstone to bigger course reform, there is precedent for the benefit of relatively small course interventions on student outcomes. Previous research focused on social or psychological factors like self-efficacy, motivation, belonging, and stereotype threat, etc., called social-psychological interventions, has been used to address specific risk factors or barriers to student success (Yeager and Walton, 2011; Walton, 2014; Spitzer and Aronson, 2015; Tibbetts et al., 2016). These social-psychological interventions have been shown to improve student performance, interest, motivation, and sense of belonging (Cohen et al., 2006; Hulleman and Harackiewicz, 2009; Hulleman et al., 2010; Walton and Cohen, 2011; Sherman et al., 2013; Harackiewicz et al., 2014; Stephens et al., 2014).

In this study we investigated the impact on student affect, e.g., belonging, science motivation, and life satisfaction, of small course interventions that capture elements of course-wide high impact practices but easily could be customized and added to existing course structures. A broader intention was that these small interventions, if effective, would serve as a less daunting gateway to the implementation of course-wide approaches in the future. Our interventions were short (15-min), weekly, facilitated, small-group discussions elicited by one or more prompts that were incorporated into the discussion sections of an introductory environmental science course and were led by undergraduate and graduate level teaching assistants. The prompts fell into two categories: (1) utility-value that promoted reflection on the relevance of course content to society and/or students' lives, e.g., climate change or food insecurity; or (2) whole-person development that invited students to consider course content in relation to their

own values, beliefs and self-perception and then reflect on how that might inform the types of career and personal development decisions they face as college students.

While there is evidence for the benefit of utility-value interventions (Hulleman and Harackiewicz, 2009; Hulleman et al., 2010; Harackiewicz et al., 2014), we were particularly interested in how the whole person development modules would perform in comparison. The whole person development prompts were inspired by and modeled after activities developed by Dr. Richard Light for his How to Live Wisely course at Harvard University (Light, 2015). Dr. Light developed this course in response to exit survey comments which indicated that students felt they had little to no opportunity to ponder and discuss life's big questions like what is the meaning of life and how to live their best lives. We hypothesized that whole-person development modules that emphasize the importance of the college experience in helping students become their best selves and live their best lives, rather than focusing solely on career or workforce preparation, would improve different aspects of student affect than are promoted by utility-value interventions.

Methodology

Course description and context

The context for this study was a four-credit hour introduction to environmental studies course at a public R1 research university in the northeast. The course covers major principles of ecology, food-chain relationships, material cycling, community structure, population regulation, ecological succession, agriculture, nutrition, forestry, and wildlife conservation. The course also considers political, economic, and ethical concerns related to the environment. The course is required for all environmental science majors and minors and fulfills the university's general education requirement for global interdependencies. The course is a mix of environmental science majors and minors and students from other degrees fulfilling their general education requirements. The course structure consists of a large enrollment (~200) lecture (three contact hours) led by the instructor of record and weekly small enrollment (15–20) discussion sections (2 contact hours) led by graduate or undergraduate teaching assistants (TAs). Discussion sections allow for a more interactive, small class experience with specific course concepts. To maximize consistency between discussion section experiences, TAs used the same instructional materials and met weekly for instruction on how to deploy the modules and facilitate student discussion.

Participants and procedure

Fifteen-minute reflection modules addressing relevance of course material or whole-person development were implemented in all discussion sections of the introductory environmental science course over three semesters (Fall 2020, Spring 2021, Fall 2021). In total, reflection modules were implemented in 34 discussion sections of 15–20 students each, involving approximately 600 students. Of this population, 214 students provided consent for use of their data according to our exempted study protocol approved by Binghamton's Board of Human Subjects Research (BU IRB Protocol #00002528). Of those 214 students, 200 completed the pre survey, 192 completed the post survey, and 178 completed both the pre and post surveys.

Reflection modules were developed by the authors and implemented by graduate and undergraduate TAs following instruction in module deployment by the lead author. Each TA taught two discussion sections, one incorporating modules devoted to making course content relevant to students' lives (REL) and the other incorporating modules focused on whole-person development (WPD). Module type was randomly assigned across each TAs set of sections. Modules generally required students to reflect on prompts, share their thoughts in small groups and report on themes to the whole class. Equal time was devoted to module activities in the two types of discussion sections with modules occurring during the first or last 15 min of weekly discussion meetings. On occasion, students were asked to reflect on specific topics at home to prepare for the following week's reflection. A tangential goal of implementing these modules was to create an open and inviting classroom environment to encourage positive community formation. Following are examples of questions that students reflected on and discussed during the different sections:

- WPD reflection prompts: What does it mean to live a good life? A productive life? A happy life? Do you expect your college experience to help you address these questions? How can/should college play a role in helping to answer these questions?
- REL reflection prompts: Why is it important to make science relevant? What scientific topics are most interesting to you? How can I use science to better myself or my community?

Materials/metrics

To measure the impact of the modules on student affect, we constructed a 35-item survey that was deployed using an institutional Qualtrics account at the beginning and end of each semester (Table 1, example items; Appendix 1, full survey). The survey included novel items that queried students' life satisfaction and expectations of college and published items that queried science motivation and sense of belonging. Survey items also collected demographic information, student major and year of college. Participation in the reflection discussions and completion of surveys were part of the normal course evaluation. As such, students received course credit for completing assignments, however there was no incentive for providing consent for the use of data as part of this study. The surveys were deployed at the beginning and end of each semester. The primary measures in the survey are summarized below:

- *College expectations:* These items queried students' expectations about whether college would help them develop holistically.
- *Life satisfaction:* These items queried students' feelings of satisfaction with life, in general.
- *Sense of belonging in science:* These items query students' personal sense of belonging in STEM.
- *Science motivation (personal & career):* These items query students' motivation for learning science for either personal or career related reasons.

TABLE 1 Description of measures.

Measure	Example	Scale	Citation
College Expectations (6 items)	"I expect college to nurture me."	5 point scale from "Not true at all" to "Totally true"	Created by the authors
Life Satisfaction (4 items)	"Having a purpose in life."	5 point scale from "Not satisfied" to "Completely satisfied"	Created by the authors
Sense of belonging in science (8 items)	"I feel that I belong to the University community."	8 point scale from "Strongly disagree" to "Strongly Agree"	Good et al. (2012)
Science Motivation-Career (3 items)	"I plan to use science in my future career."	5 point scale from "Never" to "Always"	Glynn et al. (2011)
Science Motivation-Personal (3 items)	"The science I learn is relevant to my life."	5 point scale from "Never" to "Always"	Glynn et al. (2011)

Analysis

To reveal students' life satisfaction, expectations of college, sense of belonging in science and science motivation, we calculated composite scores for each of our survey measures and used descriptive statistical analysis to calculate mean responses to these composite answers for both the pre- and post-surveys. Prior to calculating composite scores, we used correlational analysis to determine the internal consistency of the items in each measure by calculating Cronbach's alpha with an acceptable cutoff of 0.70 (Cortina, 1993). The items in all of our novel and previously published measures demonstrated internal consistency above 0.70 except for sense of belonging. Two of the original survey items were removed from analysis for the sense of belonging measure in order for this measure to meet our accepted level of internal consistency.

We next performed exploratory factor analysis, using the principal axis factoring method and a varimax rotation, on the items of each measure to determine if the items behaved as single or multiple factors. The items in all of our measures except science motivation loaded as single factors. As a result of the exploratory factor analysis results, the original six-item science motivation measure was subdivided into two 3-item measures that focused on science motivation related to career and science motivation related to personal value. Once metrics loaded as a single factor, after meeting the initial threshold for internal consistency, individual item scores were summed to create a composite measure score for each student (Comrey and Lee, 1992; Table 2).

To determine if aspects of student identity had an impact on responses to our measures, we used the Kruskal Wallis H test (KWt) to compare average composite scores to the various measures across groups defined by the following demographic factors: gender, ethnicity and parental college attendance (as a proxy for first generation students). We carried out this analysis to compare average composite scores for the measures by those same demographic groups for the post-survey to determine if response frequencies were different at the end of the semester. We calculated mean difference scores for each measure by subtracting a student's pre-composite score from their post-composite score for a given measure and averaging across the entire measure. A Wilcoxon signed rank test (WSR) was then used to compare the differences between the pre−/post-changes in mean scores for participants. Multiple regression analysis was conducted to determine the relationship between independent variables like module type or student social demographics and changes in responses to the study measures across the semester. All statistical tests were run on SPSS v 27.0.

TABLE 2 Descriptive statistics, exploratory factor analysis, and Cronbach's alpha for measures.

Measure	Time	*N*	Mean	S.D.	EFA	α
College Expectations (CE) 5-point Likert scale (1–5). Max score: 30	Pre	200	24.5	3.6	Loaded as single factor; 0.36–0.78	0.76
	Post	192	24.8	3.6	Loaded as single factor; 0.37–0.84	0.78
Life Satisfaction (LS) 5-point Likert scale (0–4). Max Score: 16	Pre	200	9.8	3.4	Loaded as single factor; 0.72–0.86	0.86
	Post	192	9.9	3.3	Loaded as single factor; 0.63–0.84	0.84
Sense of Belonging (SB) 8-point Likert scale (1–8). Max score: 64	Pre	200	34.7	7.2	Loaded as single factor; 0.49–0.83	0.76
	Post	192	34.4	7.5	Loaded as single factor; 0.53–0.87	0.76
Science Motivation-Career (SM-C) 5-point Likert scale (1–5). Max score: 15	Pre	200	12.8	2.5	Loaded as single factor; 0.72–0.99	0.73
	Post	192	12.8	2.4	Loaded as single factor; 0.83–0.85	0.87
Science Motivation-Personal (SM-P) 5-point Likert scale (1–5). Max score: 15	Pre	200	12.1	2.0	Loaded as single factor; 0.75–0.83	0.87
	Post	192	12.3	1.8	Loaded as single factor; 0.56–0.89	0.75

TABLE 3 Respondent characteristics.

Year (%)	Gender (%)	Ethnicity (%)	College attendance by parents (%)
Freshmen 47	Women 66	White 73	Both 56
Sophomore 29	Men 31	Asian 12	Neither 21
Junior 19	Nonbinary 3	Hispanic 7	Mother only 15
Senior 5		Multi 5	Father only 8
		Black 3	

TABLE 4 Difference scores for science motivation (SM-C and SM-P) and sense of belonging (SB).

	Group	SM-C	SM-P	SB
Gender	Women	−0.04	0.58*	0.8
	Men	−0.13	−0.48	−1.65
Ethnicity	White	−0.15	0.04	−0.49
	Asian	0.2	0.35*	0.6*
	Hispanic	−0.33	1.17	2.4
	Multi-ethnic	0.2	0.7	1.1
	Black	0.50	1.33	0.50
First Generation Proxy	Both	−0.04	0.33	0.27
	Neither	0.15	0.85*	1.26
	Mother	−0.37*	−0.93	−1.26
	Father	−0.27	−0.07	−2.47

*$p \leq 0.05$.

Results

The goal of this study was to determine the impact of small psycho-social course interventions highlighting whole-person development on student life satisfaction, college expectation, sense of belonging in science and science motivation. These interactive modules were designed to engage students in reflection and discussion related to either (a) the relevance of course topics to students' lives, or (b) the role of college in promoting whole-person, not just work-force, development. The 15-min modules were implemented in weekly, small enrollment discussion sections of a large enrollment introduction to environmental science course. Approximately 600 students took part in these discussion modules over the course of three semesters and submitted pre- and post-surveys focused on student affect as part of the normal course evaluation. Approximately one-third of the students provided consent for their data to be used and took the pre- ($n = 200$) and post-surveys ($n = 192$). This cohort comprised predominantly White, women, freshmen whose parents attended college (Table 3).

Student affect in an introductory college STEM class

On average, students in an introductory environmental science course at a northeastern research university during the pandemic reported relatively high expectations for their college experiences (mean composite score ~ 25/30) and their motivation for science related to their careers (~13/15) and personal lives (~12/15) both before and after taking part in the course (Table 2). The measure of expectations for college related to their belief that college would nurture them, aid in their personal and professional development, contribute to their success and help them become more global citizens. The measure of motivation for science related to careers encompassed their belief that science would be part of their careers and that understanding science and having science skills would benefit their careers. The measure for motivation for science related to their personal lives included their enjoyment of learning science and their belief that science is both relevant to their lives and makes their lives more meaningful. By contrast, students' life satisfaction (~10/16) and sense of belonging in science (35/64) were, on average, relatively low both before and after the course. The life satisfaction measure comprised students' sense of joy, personal growth and fulfillment of purpose and personal dreams. The measure of sense of belonging addressed students' feelings of being respected, valued, supported and content, as well as their joy in being an active participant at their institutions. These results were not significantly different for students who experienced the two different types of psycho-social intervention.

We were curious to know if factors that impact student social identity such as gender, ethnicity or family experience with college had an impact on student responses. When separated by gender, women reported significantly higher expectations that college would nurture them than men ($p = 0.003$; KWt). This trend remained in the post-survey ($p < 0.001$) regardless of the psycho-social intervention type. Asian students reported significantly lower life satisfaction than their White counterparts ($p = 0.003$) at the beginning of the semester, however, this difference disappeared in the post-survey. The post-survey results were not significantly different based on intervention type. Asian students also reported a significantly lower sense of belonging than did Hispanic ($p = 0.043$) or White ($p = 0.006$) students. This difference also was not found in the post-survey, regardless of intervention type.

Changes in student affect across the semester

Of our five measures, only motivation for science relative to students' personal lives showed a significant increase ($p = 0.05$) across all students in either intervention type, however the effect size is small (0.1). When differences between pre- and post-scores for the difference measures were compared across groups separated by social demographic factors, nuances were revealed (Table 4). Asian students, women, and students with neither parent attending college demonstrated significant increases in personal science motivation ($p = 0.02$, $p = 0.05$, $p = 0.04$, respectively). By contrast, students whose mothers were the only parent to attend college reported a significant decrease in science motivation related to career, independent of the type of intervention module ($p = 0.03$). The sense of belonging experienced by Asian students increased significantly ($p = 0.03$) regardless of whether they took part in the relevance or whole-person development modules.

Discussion

Our project is founded on the idea that college should be a place for students to develop holistically – growing personally and professionally as thinkers, doers, and citizens. All too often, students' college experiences fail to reflect this more holistic, transformative view (Fischman and Gardner, 2022; Sparks, 2023). Undergraduate careers are more often filled with lecture-based courses siloed by subject where students lack opportunities to engage with material, build skills they can use outside the classroom, or make connections across disciplines or with societal problems (Stains et al., 2018). To counterbalance this transactional conceptualization of the purpose of the college experience, our interventions, particularly our whole-person development modules, were intended to give students the opportunity to ponder the role of college in their lives and the way they can use the information they learn in class to better themselves, their communities, and society. With a goal of reducing the negative impacts of the systemic inequities present in higher education, our whole person development modules also signaled the instructors' value of student's personal development and gave students the opportunity to build community, with the ultimate goal of increasing belonging.

Based on the reported benefits of other small psycho-social interventions, that include increased academic competence, effort contribution, interest, and motivation, we expected to see improvements in aspects of student affect as a result of our interventions (Linnenbrink-Garcia et al., 2016). But, given the differing natures of the two interventions, we anticipated the impacts to differ as well. Contextualizing course content for students can help them develop positive identities with science, increase learning gains, and reduce attrition (Robbins et al., 2004; Richardson et al., 2012; Hulleman et al., 2016). Therefore, we predicted that the discussions of content relevance might drive improvements in science motivation and sense of belonging in science, in accordance with previous interventions of this type (Kalender et al., 2019; Chen et al., 2021). Student decisions to persevere in the sciences is intimately tied to their perception of belonging in the world of STEM and their motivation to learn in these environments. Our relevance interventions directly encourage this type of thinking in students by placing their lessons, and ultimately the course, within a context that allows them to relate to professionals and alternative careers in the field. Likewise, we expected our whole-person development modules would spark increases in life satisfaction and in students' expectations that college should nurture them holistically.

Given that this course serves as a requirement for environmental science majors and minors, it is not surprising that the students started out with a high motivation for science both personally and professionally. However, we were surprised to see that students entering our course reported relatively high expectations for their college experiences to nurture them and develop both holistically and professionally. According to our own anecdotal experiences with students and findings by Fischman and Gardner (2022), the majority of students perceive college as a preparation for higher-paying jobs more so than an opportunity to grow as a person. This difference may be explained by the large proportion of our audience being first-year students. In Fischman and Gardner's study, the increased representation of more experienced students may reflect the influence of the actual college experience on students' perceptions of the purpose of college. The high average starting levels of students' science motivation and college expectation may in part explain the lack of large changes in these two measures across the semester. This may also have eliminated an opportunity to distinguish nuanced differences in the impacts of the two different types of modules.

Taking into consideration the pandemic backdrop for our study, the low levels of student life satisfaction were not surprising. The Fall 2020 semester (the first of this study) was the first complete semester to take place during the Covid-19 pandemic. Courses met exclusively online after a summer defined by lockdowns and public safety protocols. Lockdowns have demonstrated negative impacts on mental health and general happiness in various populations around the world (Amerio et al., 2020; Rossi et al., 2020; Panchal et al., 2021), impacting students in our courses as well. Given the extreme, unprecedented situation caused by the pandemic, it may be too much to ask of small course interventions to offset its impact related to life satisfaction across our student population.

Since small interventions of the type deployed in our study have been shown to benefit historically excluded groups (Hulleman et al., 2010; Diekman et al., 2011), we were not surprised to see nuances arise when we analyzed responses of different social groups separately. The fact that women had higher expectations of college nurturing their development than men may be related to findings that women have higher educational and vocational aspirations than men (Mau and Bikos, 2000). In addition, the increase in women's personal science motivation across the semester may be related to the increased importance that women place on communal affordance (Diekman et al., 2010, 2011; Boucher et al., 2017) and the fact that both of the sets of modules allowed students to contemplate their life goals, whether personal or professional, in the context of the course. While Asian students do not typically fall into categories of historically excluded groups in STEM, this demographic exhibited significantly lower life satisfaction and sense of science belonging at the beginning of the semester. As such, this finding may, at first glance, seem surprising, however, the anti-Asian sentiment observed during the pandemic likely played a role. At the start of the pandemic, rises in racism against Asians were seen globally (Gover et al., 2020; Strabucchi and Chan, 2020). Increased racist acts against Asians likely negatively impacted general life satisfaction for these students in addition to increased ostracization leading to a lower sense of belonging. We were heartened to see significant improvements for Asian students in both life satisfaction and science belonging over the course of the semester, and to reinforce findings from prior studies on small psyco-social interventions that demonstrate how a low time-commitment intervention can have a significant impact on students' affect. An important limitation to note in the collection of demographic data on ethnicity is our decision to group Asian students into a single variable. We recognize that collapsing the diversity of Asian ethnicities into the one category is not desirable and certainly misses distinctions in diverse background and experiences. However, in order to have a stronger variable for data analysis purposes given the low number of Asian students, we were forced to group them all as a single variable. We feel that this allowed us to make more concrete assertions on the impact of our interventions on students as a whole.

In conclusion, our study reinforces prior work on the positive impact of embedding course content in societally relevant contexts and contributes novel findings on the benefits of small psycho-social interventions that center whole-person development. For both types

of interventions in our study, the importance of student development, primarily professional for the content relevance modules and primarily personal for the whole-person development modules, was conveyed to students explicitly through messaging and implicitly through class time devoted to the modules. We believe that the similarity in benefits of both types of modules was in part due to building community with peers and the perception of a positive relationship with the instructor which has been shown to impact student outcomes such as motivation and engagement (Umbach and Wawrzynski, 2005; Komarraju et al., 2010; Cavanagh et al., 2018). In addition to the benefits that we measured, we hope that these interventions helped students find meaning and value in their course experience. Considering Graham et al. (2013) framework that identifies learning and professional identification as determinants of persistence in STEM, module implementation gave environmental studies students time to reflect on their growth, learning, and the role of science in their lives. While small interventions of this type can be beneficial, they alone are not sufficient to address the systemic barriers and discrimination faced by historically excluded groups in STEM fields. Therefore, we hope that they serve as an accessible first step for larger course and curricular reforms.

Recommendations for practice

These results strengthen prior work demonstrating that small psycho-social interventions can significantly benefit student affect while requiring a relatively low time-commitment and can be administered effectively by teaching assistants. The body of literature on this topic shows that there is not a one size fits all approach to this type of practice (Canning et al., 2018). Therefore, it is recommended that instructors take a backward design (Wiggins and McTighe, 1998) approach to incorporating these types of modules into existing classes. A backward design approach entails first identifying intended goals and outcomes to guide decisions about (a) how to evaluate the impact of your intervention and (b) what form your intervention will take. To identify a goal, the following should be answered: what do you hope to achieve by including this intervention in your course? Do you wish to generally improve some aspect of student affect or performance or is there a specific issue that you wish to address such as performance or persistence disparities along the lines of a social determinant such as gender, ethnicity, or socioeconomic status? If unsure about whether there are demographic based disparities in student outcomes for the course, a needs assessment should be performed that includes disaggregating course grades for prior semesters based on demographic factors and/or surveying current students with questions from a published metric such as the ones used in this study or in the studies cited in this paper.

Once a goal is determined, identifying expected outcomes follows. For example, if the intervention successfully addresses a previous failure to emphasize the importance of student development or how course materials relate to students' career or life preparation, then one might expect to see an increase in student sense of belonging, motivation, or appreciation for the relevance of the course topic. Alternatively, if the intervention successfully mitigates a socially oriented systemic barrier to success in the course or at the institution, one might expect to see improvements in persistence or performance by particular demographic groups. The beauty of defining specific intended outcomes is that they clarify choices about how to evaluate and enact your intervention. For example, if one expects student belonging to increase as a result of the intervention, then a pre−/post-survey on belonging can be used to evaluate the intervention's impact. The studies cited in the introduction and discussion sections of this article provide a set of resources from which to find metrics and methods for evaluating a multitude of desired student outcomes. Likewise, Supplementary material from this study and the studies cited here provide examples of interventions that can be deployed in various classes. In addition, resources such as the Science Education for Civic Engagements and Responsibilities initiative, the Inclusive STEM Teaching Project and Richard Light's course description are a few examples of useful resources for promoting course relevance and civic responsibility, belonging and inclusion, and whole-person development, respectively. Generally, interventions will take the form of in-class discussions or formal writing assignments at periodic intervals throughout the semester. The way in which these reflection activities are structured is based on the preference of the instructor and the needs of their students. Regardless of the specific content of discussion/writing prompts, taking class time to promote and facilitate student reflection and discussion of these topics will improve engagement and signal value to student development and success. To promote consistency across multiple courses or course sections, the instructor or instructor team should develop the module materials and provides training for the teaching assistants who will deploy the modules. Perceptions of the value of these modules both personally and for their students by teaching assistants will be reported in a future manuscript.

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 SUNY Binghamton IRB Committee – Michelle Lukovitch. 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

EM and MW contributed to the conception and design of the study, edited and wrote sections of the manuscript. EM performed the statistical analysis and wrote the first draft of the manuscript. All authors contributed to the manuscript revision, read, and approved the submitted version.

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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.2023.1177033/full#supplementary-material

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