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Persistence of STEM Majors in Higher Education

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Abstract: Students in STEM programs often face difficult or 'weed out' courses in their first year of declaring their major and are frequently confronted with academic threats. The U.S. is estimated to need at least 1 million more STEM majors to meet the growing job market in STEM fields, and nearly 60% of students who declare a STEM major eventually switch to a non-STEM major or leave without any degree. Drawing on self-affirmation theory, this quantitative study explores the role that academic confidence and a sense of belonging play in STEM major persistence through a lens self-affirmations. 54 undergraduate students participated in a pre-test/post-test survey with a double-blind affirmation intervention in an introductory chemistry I course. Findings revealed a remarkably high STEM major persistence rate of 102%, but no statistically significant findings, challenging the notion of standalone affirmation interventions as a quick solution for retention. While the intervention did not yield statistically significant results, post-test belonging scores suggest a more significant influence on persistence than academic confidence. The study underscores the complexity of promoting STEM major persistence and the need for multifaceted approaches. Future research could explore longitudinal impacts and mechanisms underlying student belonging to develop more effective retention strategies.

Keywords: STEM, Affirmation, Belonging, Academic confidence, Persistence
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Introduction

The fields of science, technology, engineering, and mathematics, commonly known as STEM, exploded in the twenty-first century. STEM professionals are at the forefront of solving complex problems and shaping the future, from developing sustainable energy solutions to designing lifesaving medical innovations. The constant growth in these fields has led to a need for more students to graduate from post-secondary schools with a STEM degree. The U.S. is estimated to need at least 1 million more STEM majors to meet the growing job market in STEM fields (PCAST, 2012), and nearly 60% of students who declare a STEM major eventually switch to a non-STEM major or leave without any degree (Graham et al., 2013).

Typically, first year STEM majors will take at least one introductory level course in Biology, Chemistry, Anatomy and Physiology, or Physics. While these courses are at an introductory level, they are typically academically rigorous and often referred to as 'weed out' courses by students and faculty alike. Research has shown that a student's poor performance, as defined by withdrawing from the course or receiving a D or F letter grade, in an Introductory Chemistry course is the biggest predictor of leaving their STEM major when compared to other traditional 'weed out' or difficult courses (Cohen & Kelly, 2019). Therefore, this study is conducted within an introductory chemistry course to investigate the factors at play and what may be impacting persistence of STEM majors.

To help bridge the one million STEM major gap, research needs to address the factors that influence persistence in these 'weed out' courses as well as STEM majors. Two influential factors of persistence are students' academic confidence and sense of belonging (Ajjawi et al., 2020; Bowden et al., 2021; Tinto, 2017). Research has shown that

affirmation positively influences these psychological factors (Estrada et al., 2019; Layous et al., 2017; Turetsky et al., 2020; Wu et al., 2021). Acknowledging the significance of these factors, this research seeks to investigate the effect of an affirmation intervention on academic confidence and belonging in relationship to STEM major persistence in an introductory chemistry course. The researcher hypothesizes that participation in an affirmation activity will positively correlate with STEM major retention into the semester following an introductory chemistry I course. Specifically, it is anticipated that students who engage in the affirmation activity will demonstrate higher levels of academic confidence and a greater sense of belonging, contributing to increased persistence in their STEM major.

Literature Review

Students must persist through their STEM major to successfully join the STEM workforce. While retention methods frequently focus on the institution, leaving students to feel like a statistic in their own lives, persistence empowers the student to take ownership of their success and stay dedicated to achieving their academic goals. Two main factors attributed to persistence are belonging and academic confidence (Ajjawi et al., 2020; Pedler et al., 2022; Tinto, 2017; Wilson et al., 2015). When students feel that they belong, they are more resilient when facing challenges and find motivation both internally and externally from their group connections. Academic confidence is closely linked to a sense of belonging. When students believe they possess the capacity to succeed academically, they are better able to tackle difficult assignments. Affirmations provide students with methods to connect and bolster their sense of belonging and academic confidence.

Persistence

Persistence refers to the ability of students to persevere through academic challenges and setbacks to continue in their course, program of study, or to graduation. Persistence differs from retention in that retention is often approached from the perspective of the university and methods or actions the school and its entities can take to retain students. Persistence research focuses on students' perspectives and places the power of striving towards their goals in their hands while acknowledging institutional practices and policies play key roles in student's success (Cromley et al., 2016; Tinto, 2017).

Student persistence is focused on the interactions and circumstances of each student's characteristics, such as confidence and attitudes; their life, such as health or employment; and the institution's role through the policies and structures in place for student success (Ajjawi et al., 2020; Riegle-Crumb et al., 2019; Suarez et al., 2021). When students encounter a life setback, their personal characteristics are a major determinant of whether they will be able to persevere through the hurdle, if they will decide to take an alternative route towards their goal or drop out of school entirely. Riegle-Crumb et al. (2019) found that compared to their White peers, Black and Latino students are less likely to switch from a Humanities major to a STEM major and are significantly more likely to switch from a STEM major to a Humanities major.

STEM persistence is a predominate sub-field of persistence research. With nearly 60% attrition rates in STEM, introductory, gateway, or 'weed out' courses are important to review (Asher et al., 2023; Graham et al., 2013). Introductory chemistry is typically one of the first science courses taken within the STEM major's first year and plays a significant role in shaping student's academic trajectories (Asher et al., 2023). Introductory Chemistry courses have also been identified as high impact courses when considering DFW rates (Cohen & Kelly, 2019; Stone et al., 2018). Grade performance is tracked through grades of D and F, as well as if students withdraw from the course, receiving a W on their transcript. Tracking this grade combination is commonly referred to as the DFW rate. When standard introductory STEM course grade performance is compared between Anatomy and Physiology, Biology, Chemistry, and Physics, Chemistry DFW rates have been shown to provide the most significant indication of STEM student persistence (Cohen & Kelly, 2019).

Belonging

Love and belonging are situated in the middle of Maslow's hierarchy of needs (Maslow, 1943). After achieving the most basic physiological needs and safety, humans seek connections and have a strong desire to belong. Many researchers have furthered this research into belonging since Maslow, but Baumeister and Leary have expanded the field immensely. In 1995, they conducted a meta-analysis and established their belongingness hypothesis. They found that belongingness is fundamental to human motivation. Humans are hard-wired to seek the feeling of belonging and it is pivotal to our emotional wellbeing. The communities in which we belong function as social coping mechanisms, where communities are support systems. When a member of the group is faced with stressful events and challenges, their belonging to this group provides support by being a member in addition to any direct, individual membership support. In the absence of spaces where someone feels they belong, they become more vulnerable to stress and are more likely to lose motivation and pursue their goals.

A sense of belonging can be felt within the classroom, in their major, at the institution, and in personal and social environments. As a student's sense of belonging increases, they are more likely to persist (Bowden et al., 2021; Dweck et al., 2014; Pedler et al., 2022; Wilson et al., 2015). With increased belongingness in a classroom setting, students are more likely to perceive instructors as supportive and organized, their motivation to succeed is statistically higher, and their academic confidence or self-efficacy increases (Flynn et al., 2016; Zumbrunn et al., 2014).

STEM majors from underrepresented backgrounds are more likely to have a lower sense of belonging in their STEM program and are at an increased risk of changing majors or dropping out of college (Beauchamp et al., 2022; Tinto, 2017). Students who have a greater sense of belonging tend to have higher academic confidence in themselves and are more likely to persist (Pedler et al. 2022).

Academic Confidence

Academic confidence is defined as a student's belief in their ability to succeed in their coursework (Pedler et al., 2022). Self-efficacy and academic confidence are used interchangeably in research. Bandura's (1977) self-efficacy

definition focuses on an individual's belief in their ability to succeed in a particular task or specific goal. Academic confidence tends to be utilized in broader and more generalizable contexts. This study utilizes the more encompassing term of academic confidence.

Research has shown that academic confidence positively correlates with academic achievement (Honicke & Broadbent, 2016). Students with low academic confidence tend to avoid academic challenges, resulting in lower academic achievement or leaving the university. However, academic confidence is not a fixed notion and student's first year experiences are critical to their construct and continued perception of academic confidence. Through influencing factors such as engagement, a sense of belonging, and perceptions of value of the curriculum, students can bolster their academic confidence and increase their likelihood of persistence (Tinto, 2017). Academic confidence positively influences academic performance in STEM courses (Cromley et al., 2016).

Women in STEM are still underrepresented and tend to leave STEM at higher rates than their male counterparts. Learning environments that encourage a sense of belonging positively correlate to increased perceptions of competence (Griffin, 2023). Through continued academic success in STEM courses, students are more likely to graduate with a STEM degree and enter their desired STEM field in the future.

Affirmations

Affirmations are self-supporting statements, values, and concepts that can be written, spoken, or thought of by individuals seeking encouragement (Layous et al., 2017). Affirmations in the classroom are useful in threatening situations, such as difficult exams, or when students may feel isolated or singled out. The affirmations allow students to reflect on their belonging to a group, or their academic capabilities that helped them enter college or succeed in other areas of their lives.

Affirmation activities have been shown to benefit students academically in many ways, such as raising the grades of first-generation undergraduates in a biology course (Harackiewicz et al., 2014) and increasing the academic achievement of underperforming low-socioeconomic status students (Hadden et al., 2019). Writing affirmations have been used specifically in STEM persistence research to show improved GPA scores (Asher et al., 2023), as well as improved biology course persistence and maintained or improved social networks (Turetsky et al., 2020). Wu et al. (2021) found that affirmation activities work best when integrated into class work as a normal classroom activity and benefit identity threatened students. These works suggest that improving student's perceptions of threats through self-affirmations may be key to increasing STEM major persistence.

Theoretical Framework

Self-affirmation theory (Steele, 1988) focuses on an individual's ability to maintain a positive concept of self by supporting their roles, beliefs, and values through adversity. When the individual is presented with a threat, they will seek to reaffirm the self through an act of affirmation. The individual does not have to engage in resolving the threat

presented, but instead tends towards maintaining the overall concept of the self as good through acts of affirmation. These threats range from large and severe, such as a natural disaster or cancer diagnosis in which the individual is unable to avoid the threat, to smaller scale threats such as hearing an insult or failing an exam.

Individuals support positive self-identity through self-affirmation interventions. Self-affirmation interventions are acts that one performs to demonstrate adequacy to the self. These acts can be internal acts of validation, such as a nurse remembering the heartfelt gratitude from a patient after hearing an insult, or external acts, such as a student helping their classmate with their homework after losing a soccer match. The size and directionality of the act vary, but the affirmation must relate to something validating to the individual. These acts function as psychological buffers against threats of failure or negative experiences.

Part of learning is failure, and self-affirmations help students mitigate the negative impact of the natural setbacks and hardships they encounter in the learning process. Affirming one's values has been shown to enhance one's feelings of self-worth and competence, which supports their continuation of the learning process (Wu et al., 2021; Yeager & Dweck, 2012). Self-Affirmation Theory acknowledges the importance of belonging and social identity in shaping individuals' self-perceptions. Affirmations can strengthen a student's sense of belonging by aligning them with values related to their academic achievement and professional aspirations. This sense of belonging can contribute to a positive academic identity and has the potential to motivate persistence (Estrada et al., 2019).

Students in STEM programs often face difficult or 'weed out' courses in their first year of declaring their major and are frequently confronted with academic threats (Cohen & Kelly, 2019). The threats can result from external sources such as poor grades, lack of understanding complex concepts, or stereotypes explicitly or implicitly expressed in the classroom. This study builds upon prior research by exploring the role that academic confidence and sense of belonging play in STEM major persistence through a lens self-affirmations.

Methods

Research Context

This study aimed to examine the effect of an affirmation intervention on students' academic confidence and sense of belonging in relation to their persistence as STEM majors. Project researchers work at a private liberal arts 4-year institution in the United States. As higher education faculty and staff, they aim to support the recruitment and persistence of students within the STEM majors at their institution and hopefully others. STEM majors within this study's context include biochemistry, biology, chemistry, engineering, exercise science, and medical lab science. Utilizing a quantitative research study design, the researchers hypothesized that students who participated in an affirmation intervention would be able to increase their academic self-confidence and sense of belonging, which would lead to their continued academic persistence as STEM majors.

Research Design

Students within an introductory chemistry I course were invited to participate in this study during the Fall 2023 semester. Volunteers across two sections of chemistry I participated in a pre-test/post-test with a double-blind affirmation intervention (Gibbons & Raker, 2019; Good et al., 2012). The institution hosts introductory chemistry in a I and II format, in which STEM degree programs require introductory chemistry I; Biology, Chemistry, and Biochemistry majors must also complete introductory chemistry II as part of their program. The pre-test/post-test surveys and affirmation activity took place during the introductory chemistry I course. Transcript data was used to discern persistence based on enrollment in the next introductory chemistry course, where required, as well as all participant's STEM major status the semester following the intervention. The pre-test/post-test survey addressed academic self-confidence and sense of belonging, and the affirmation activity served as the intervention.

Academic self-confidence and sense of belonging were measured using portions of the Chemistry Self-Concept Inventory (Gibbons & Raker, 2019) and the Math Sense of Belonging Scale (Good et al., 2012). Gibbons and Raker's (2019) inventory rates above acceptable coefficient alpha scores of .70 (p. 609), indicating good reliability. Good, Rattan, and Dweck (2012) established internal reliability and consistency for each item used in the Math Sense of Belonging Scale. The selected items from each scale were identified as most relevant to the research topic and the survey was pilot tested by a group of seven graduate students.

The survey asked students to use a seven-point Likert scale to rate the accuracy of statements surrounding academic confidence and sense of belonging, from Very Inaccurate to Very Accurate, with five additional questions related to demographic data, including declared major. Academic confidence was defined as a student's sureness in their success in their coursework. This section's prompts included phrases such as, "I expect to do well in this class" and, "I'm certain I can understand the most difficult material presented in the readings for this course". A sense of belonging was explained to students as "how you feel about a group and your membership in it". The sense of belonging questions included phrases such as, "I feel a sense of belonging with the Chemistry community" and "A sense of belonging makes difficult classes feel easier".

Persistence was defined as continuation and measured by student's declared STEM major and enrollment in the next introductory chemistry course the semester following the intervention. Majors were categorized as either STEM (Science, Technology, Engineering, and Mathematics) or non-STEM. STEM majors encompassed disciplines such as Biochemistry, Biology, Chemistry, Civil Engineering, Exercise Science, Mechanical Engineering and Medical Lab Science. Non-STEM majors included Nursing, Psychology, Spanish, and Undeclared. It is important to note that while Nursing and Psychology can be considered STEM majors in certain contexts, they were classified as non-STEM for the purposes of this research. This classification was based on institutional designation where this research was conducted. Specifically, the institution does not classify Nursing as a STEM major, and Psychology is only offered as a Bachelor of Arts degree.

Participants

The study took place at a private, midwestern university where 87 undergraduate students were enrolled in an introductory chemistry I course. Of those students, 72 (83%) provided consent and completed the phase one pre-test survey and affirmation activity. At the end of the semester, 54 (75%) participants who completed phase one activities completed the post-survey. The course was comprised of a majority of female participants (59%). The students were predominantly White (74%) or Hispanic/Latino (15%). Students ranged in age from 18 to 28 years old, where 61% were age 18 and 20% were age 19. 44% of students identified as Christian, 35% Catholic,11% hold no religious identity, and 13% identified with other religions. 87% of the students declared a STEM major, 13% declared a non-STEM major or were undeclared.

Data Collection and Analysis

The data was collected in three phases. In phase one, students completed the online pre-test survey prior to the one-time, double-blind affirmation intervention during week two of the sixteen-week introductory chemistry course. The graduate student researcher visited both sections of the introductory chemistry I course to administer the survey and intervention as part of an in class activity prior to the first unit exam of the course. Students were informed of the activities and those who did not consent to participate were asked to study silently. A QR code was displayed in class and a link to the survey was provided within the course's LMS platform. Students who agreed to participate in the study completed the pre-test survey on their personal devices.

Once students completed the pre-test survey, they were handed a sealed packet with an affirmation activity inside. Equal versions of the control and intervention affirmation activities were placed in unmarked packets, and then students randomly selected a packet. Each packet included instructions to complete the activity and provided space for the students to write in their answers. All students received the same 11 personal characteristics and values such as "independence" or "relationships with friends or family" and were asked to rank them in order of personal importance. Students in the intervention group were asked to write for 15 minutes about why their top-ranked personal value or characteristic was most important to them. The control group spent the same 15 minutes writing about why their ninth ranked value or characteristic might be someone else's most important value or characteristic.

In alignment with self-affirmation theory, the students in the intervention group were asked to reflect upon a personal value or characteristic that is most important to them. With the pending unit exam acting as an external threat, students in the intervention group were asked to self-affirm by focusing on this personal value or characteristic to help remind them of their goodness and to reduce the negative aspects the looming threat provided. The students in the control group were asked to reflect upon their ninth ranked value or characteristic. The ninth ranked value or characteristic was found to be a neutral item in the ranking and therefore acted as a control measure.

In phase two, during week fifteen of the same semester, the graduate student researcher returned to the introductory chemistry I sections and asked students to complete the academic confidence and belonging survey again to collect

post-test data. A QR code was displayed in the classroom and a link to the post-test survey was provided in the course LMS. Lastly, in phase three, after the add/drop period of the following semester, a report was gathered from the Registrar's Office identifying each student participant's declared major and enrollment status in the next introductory chemistry course. The add/drop time frame is provided to students to readjust their schedule based on any need or personal changes, such as changing majors. The collection of data after the add/drop period was used to ensure that all student persistence records accurately reflected the student's intent to persist through the semester both in course enrollment and major declaration.

Due to the need to correlate pre- and post- test survey responses with student's affirmation activity responses and their persistence information, students provided identifiable information on their pre- and post- test surveys and their affirmation activity. To ensure anonymity, the student's identifiable information was replaced with a unique identifier. This allowed for participant confidentiality while maintaining consistency within the data.

Once the data was obtained, the information was loaded into SPSS for statistical analysis. All data was aligned using the unique identifier to ensure each student's data was correctly correlated with their pre- and post-test survey results, their affirmation activity responses, and their major and enrollment in the next introductory chemistry course. Pre- and post-test survey results were reviewed for normality and variance with no cases excluded from the analysis. Total section scores were obtained for academic confidence and belonging as well as a total score for all items on the pre- and post-test surveys. Descriptive statistics were used to identify the persistence of STEM majors and the persistence into introductory chemistry II. An Independent t-test was conducted to compare the control and test groups with the post-test total score, the post-test academic confidence total, and the post-test belonging total. A paired sample t-test was run on each item of the pre- and post-test survey. This allowed the researcher to identify any statistically significant differences in academic self-confidence and sense of belonging between the pre- and post-test surveys. An Independent t-test was conducted to identify any significance based on the participant's affirmation group and their post-test results.

Results

The national average for STEM major persistence is roughly 40% (Graham et al., 2013), but this study found a STEM major persistence rate of 102%. Not only did all 47 STEM majors persist into the following semester, one of the seven initial non-STEM majors changed their major to STEM by the following semester. Biology, Chemistry, and Biochemistry majors must complete introductory chemistry II as part of their program. Of the final 48 STEM majors, 28 were required to complete introductory chemistry II based on their major. 89% of those required to take introductory chemistry II enrolled in the course the following semester. Both findings far exceed the national average STEM retention rate.

To examine the academic confidence and belonging score of chemistry I students and the possible impact of an affirmation activity intervention, an independent t-test and a paired sample t-test were conducted. The independent t-

test was used to discern the impact the affirmation activity had on participant's post-test academic confidence score, post- test belonging score, and their overall post-test score. As shown in Table 1, participants who received the affirmation intervention demonstrated no statistically significant difference than their control group classmates in their post-test academic confidence scores $t(52)= -.34$, $p = .74$, post-test belonging scores $t(52)= -1.11$, $p = .27$, nor their overall post-test score $t(52)= -.73$, $p = .47$. Based on the drastically elevated persistence rates and the lack of statistically significant findings when comparing the test and control groups, it is unlikely that a single affirmation intervention is the most impactful strategy to increase STEM major retention (Turetsky et al., 2020).

Table 1

Post- Test Independent T-Test Score Correlations

		M	*n*	*SD*	*p*
Post-Academic Confidence Score					.74
	Test	39.18	22	12.03	
	Control	40.34	32	12.81	
Post-Belonging Score					.27
	Test	31.23	22	9.31	
	Control	33.59	32	6.34	
Post-Test Total Score					.47
	Test	70.41	22	20.07	
	Control	73.94	32	15.56	

Although the results of the independent t-test revealed that there was no statistically significant impact of the affirmation activity on academic confidence or belonging, it is interesting to note how much closer to significance the belonging scores were than the academic confidence scores (Table 1).

To explore this difference in section scores, a paired sample t-test was conducted for each item of the pre-and post-test survey. Three item pairs revealed a statistically significant correlation. "I feel a sense of belonging with the Chemistry community" ($r = 0.278$, $p = .042$), "A sense of belonging is helpful with my studies" ($r = 0.269$, $p = .049$), and their declared major ($r = 0.741$, $p < .001$).

The moderate positive correlation of the "I feel a sense of belonging with the Chemistry community" item suggests that individuals who reported higher levels of belonging with the Chemistry community at the beginning of the semester were likely to maintain or increase their sense of belonging with the Chemistry community throughout the semester. Similarly, individuals who reported feeling a general sense of belonging helps their academic endeavors at the pre-test stage were likely to maintain or experience an increase in this belief at the post-test stage. Their declared major revealed a strong positive and highly significant correlation, indicating that their declared STEM major was likely to persist through the semester.

Table 2

Pre- and Post-Test Paired Sample T-Test Score Correlations

		n	Correlation	*p*
Pair 1	I believe I will receive an excellent grade in this class.	54	0.14	0.31
Pair 2	I'm certain I can understand the most difficult material presented in the readings for this course.	54	0.05	0.72
Pair 3	I'm confident I can understand the basic concepts taught in this course.	54	-0.10	0.49
Pair 4	I'm confident I can understand the most complex material presented by the instructor in this course.	54	0.08	0.55
Pair 5	I'm confident I can do an excellent job on the assignments and tests in this course.	54	-0.01	0.92
Pair 6	I expect to do well in this class.	54	0.08	0.58
Pair 7	I'm certain I can master the skills being taught in this class.	54	0.07	0.60
Pair 8	Considering the difficulty of this course, instructor and my skills, I think I will do well in this course.	54	0.15	0.28
Pair 9	In general, I feel a sense of belonging in my community.	54	0.20	0.15
Pair 10	I feel a sense of belonging with the [University] community.	54	0.20	0.15
Pair 11	I feel a sense of belonging with the Chemistry community.	54	0.28	0.04**
Pair 12	I feel a sense of belonging with the STEM community.	54	0.19	0.16
Pair 13	A sense of belonging is helpful with my studies.	54	0.27	0.05**
Pair 14	A sense of belonging makes difficult classes feel easier.	54	0.22	0.11
Pair 15	STEM major or non-STEM major	54	0.74	<0.001***

Note: *Pairs 1-8 relate to Academic Confidence. Pairs 9-15 relate to Belonging.*

An additional point of interest is the similar results to the independent t-test, where belonging shows a stronger correlation and is closer to significance than academic confidence. As seen in Table 2, three of the belonging pairs reach significance of at least $p < .05$, with the other four items within .11 of significance. In relation to the academic confidence pairs, ranging from $p = .28$ to $p = .92$; the significance levels of the belonging questions imply a student's sense of belonging impacts persistence more significantly than academic confidence.

Discussion

Introductory chemistry courses can create a barrier for STEM majors, resulting in a lack of persistence. Affirmation interventions have yielded positive outcomes, including heightened sense of belonging, and increased persistence in science career pathways. This study aimed to assess the impact of an affirmation activity on academic confidence and belonging in relation to STEM major persistence. Contrary to expectations, the results revealed no significant impact of the affirmation activity intervention on STEM major retention. However, the study found a 102% STEM major persistence rate, which is roughly a 62% increase in persistence compared to the national average, which makes the

results a case in which to explore academic confidence and a sense of belonging in chemistry 1 students who persist as STEM majors.

The post-test belonging scores were closer to significance than the post-test academic confidence scores, with some of the individual post-test belonging items reaching significance. This suggests a student's sense of belonging impacts persistence more significantly than academic confidence when considering STEM major persistence. With the lack of significance of the affirmation activity, but with such a high rate of persistence, it's important to consider the environmental components at play as well. Dweck, Wilson, and Cohen (2015) used the term 'academic tenacity' to refer to a student's motivation and drive that allows them to persist towards their goals. This drive stems from the student's mindset, goal setting, belonging, affirmation, and self-regulation. Schools and educators can work to help foster an environment that helps students develop and strengthen these skills. In acknowledging the environment of the study, campus initiatives and classroom culture should be reviewed.

During the time frame of the study, the campus was actively engaged in building a community of support for their students through the institution's mission and values, as well as concerted campaigns to promote community and belonging on campus. Vega and Meaders (2023) found that communication campaigns play an important role in student's information networks on campus. Students with lower feelings of belonging on campus and are less likely to seek out resources or spaces to belong on their own. One of the most successful communication methods from the university where this research was conducted was a text campaign. Students were sent periodic texts each semester asking students how they were feeling. Based on the student's response, the student is provided with suggestions on campus resources to use and how they can engage with them. If the student indicates they need additional assistance through their response, their name is provided to the student success network and someone on that student's support team reaches out directly to provide more specialized support based on their needs.

Classroom culture is driven by the instructor and the messages they communicate with their students. Both instructors of their respective sections actively worked to meet the campus goals of fostering community within their classroom. They shared personal stories, their availability outside of the class to provide additional support, as well as encouraging the use of campus resources such as the Supplemental Instructor (SI) program and the tutoring services. The SI program pairs an SI leader to a course where they hold weekly peer mentoring sessions specific to the course. The SI leader is a current undergraduate student who has taken the course in a prior semester and received an A.

Conclusion

These campus and classroom efforts work together to promote community and a sense of belonging on campus. While a standalone affirmation intervention may not be sufficient to impact STEM major persistence, affirmations can be integrated into broader support initiatives aimed at fostering a positive learning environment, enhancing academic self-confidence, and strengthening students' sense of belonging within the classroom, the institution, and the STEM community at large.

When comparing the study's population to similar studies conducted at larger public institutions with several hundred or thousand participants, this study was limited in scope. The unexpected community building initiatives on the campus also limited the ability of this study to isolate sense of belonging from these initiatives. However, looking forward, a longitudinal study exploring the impact of these classroom and campus initiatives on students' academic confidence and sense of belonging could yield valuable insights.

Overall, these findings underscore the complexity of promoting STEM major persistence and highlight the need for a multifaceted approach that addresses various factors influencing persistence. The non-significant results challenge the notion that standalone affirmation interventions may serve as a quick solution for addressing STEM major persistence. There is a need for a more nuanced understanding of the mechanisms underlying student belonging and its relationship to persistence.

References

Ajjawi, R., Dracup, M., Zacharias, N., Bennett, S. & Boud, D. (2020). Persisting students' explanations of and emotional responses to academic failure. *Higher Education Research & Development*, *39*(2), 185-199. https://doi.org/10.1080/07294360.2019.1664999

Asher, M. W., Harackiewicz, J. M., Beymer, P. N., Hecht, C. A., Lamont, L. B., Else-Quest, N. M., Priniski, S. J., Thoman, D. B., Hyde, J. S., & Smith, J. L. (2023). Utility-value intervention promotes persistence and diversity in STEM. *PNAS, 120*(19), 1-6. https://doi.org/10.1073/pnas.2300463120

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215. https://doi.org/10.1037/0033-295X.84.2.191

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as fundamental human motivation. *Psychological Bulletin, 117*(3), 497-529. https://doi.org/10.1037/0033-2909.117.3.497

Beauchamp, A. L., Roberts, S., Aloisio, J. M., Wasserman, D., Heimlich, J. E., Lewis, J. D., Munshi-South, J., Clark, J. A., & Tingley, K. (2022). Effects of research and mentoring on underrepresented youths' STEM persistence into college. *Journal of Experiential Education, 45*(3), 316-336. https://doi.org/10.1177/10538259211050098

Bowden, J. L., Tickle, L., & Naumann, K. (2021). The four pillars of tertiary student engagement and success: A holistic measurement approach. *Studies in Higher Education, 46*(6), 1207-1224. https://doi.org/10.1080/03075079.2019.1672647

Cohen, R., & Kelly, A. M. (2019). Community college chemistry coursetaking and STEM academic persistence. *Journal of Chemical Education, 96*, 3-11. https://doi.org/10.1021/acs.jchemed.8b00586

Cromley, J. G., Perez, T., & Kaplan, A. (2016). Undergraduate STEM achievement and retention: Cognitive, motivational, and institutional factors and solutions. *Policy Implications of the Brain and Behavioral Sciences, 3*(1), 4–11. https://doi.org/10.1177/2372732215622648

Dweck, C. S., Walton, G. M., & Cohen, G. L. (2014). Academic tenacity: Mindsets and skills promote long-term learning. Bill & Melinda Gates Foundation.

Estrada, M., Young, G. R., Nagy, J., Goldstein, E. J., Ben-Zeev, A., Marquez-Magana, L., & Eroy- Reveles, A. (2019). The Influence of microaffirmations on undergraduate persistence in science career pathways. *CBE-Life Sciences Education, 18*(3), 1-15. https://doi.org/10.1187/cbe.19-01-0012

Gibbons, R. E., & Raker, J. R. (2019). Self-beliefs in organic chemistry: Evaluation of a reciprocal causation, cross-lagged model. *Journal of Research in Science Teaching*, *56*(5), 589-618. https://doi.org/10.1002/tea.21515

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology, 102*(4), 700-717. https://doi.org/10.1037/a0026659

Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A. B., & Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science, 341*(6153), 1455-1463. https://doi.org/10.1126/science.1240487

Griffin, C. R. (2023). Women's sense of belonging in undergraduate calculus and the influence of (inter)active learning opportunities. *Journal of Research in Science, Mathematics, and Technology Education, 6*(2), 65-82. https://doi.org/10.31756/jrsmte.622

Hadden, I.R., Easterbrook, M.J., Nieuwenhuis, M., Fox, K.J. & Dolan, P. (2019) Self-affirmation reduces the socioeconomic attainment gap in schools in England. *British Journal of Educational Psychology, 90*(2), 517–536. https://doi.org/10.1111/bjep.12291

Harackiewicz, J.M., Canning, E.A., Tibbetts, Y., Giffen, C.J., Blair, S.S., Rouse, D.I., & Hyde, J. S. (2014). Closing the social class achievement gap for first-generation students in undergraduate biology. *Journal of Educational Psychology*, *106*(2), 375–389. https://doi.org/10.1037/a0034679

Honicke, T., & Broadbent, J. (2016). The influence of academic self-efficacy on academic performance: A systematic review. *Educational Research Review, 17*, 63-84. https://doi.org/10.1016/j.edurev.2015.11.002

Layous, K., Davis, E. M., Garcia, J., Purdie-Vaughns, V., Cook, J., & Cohen, G. L. (2017). Feeling left out, but affirmed: Protecting against the negative effects of low belonging in college. *Journal of Experimental Social Psychology, 69*, 227-231. https://doi.org/10.1016/j.jesp.2016.09.008

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review, 50*(4), 370-396. https://doi.org/10.1037/h0054346

Pedler, M. L., Willis, R., & Nieuwoudt, J. E. (2022). A sense of belonging at university: Student retention, motivation and enjoyment. *Journal of Further and Higher Education, (46)*3, 397-408. https://doi.org/10.1080/0309877X.2021.1955844

President's Council of Advisors on Science and Technology (PCAST). (2012). Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Executive Office of the President. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-executive-report-final_2-13-12.pdf

Sellami, N. Toven-Lindsey, B., Levis-Fitzgerald, M., Barber, P., & Hasson, T. (2021). A unique and scalable model for increasing research engagement, STEM persistence, and entry into doctoral programs. *CBE- Life Sciences Education, 20*(1), 1-11. https://doi.org/10.1187/cbe.20-09-0224

Steele, C. M. (1988). The psychology of self-affirmation: Sustaining the integrity of the self. *Advances in Experimental Social Psychology, 21*, 261-302. https://doi.org/10.1016/S0065-2601(08)60229-4

Tinto, V. (2017). Reflections on student persistence. *Student Success, 8*(2), 1-8. https://doi.org/10.5204/ssj.v8i2.376

Turetsky, K. M., Purdle-Greenaway, V., Cook, J. E., Curley, J. P., & Cohen, G. L. (2020). A psychological intervention strengthens students' peer social networks and promotes persistence in STEM. *Science Advances, 6*(45), 1-10. https://doi.org/10.1126/sciadv.aba9221

Vega, Y., & Meaders, C. L. (2023). Have you heard about this? An exploration of instructor communication about campus resources to students in biology courses. *Journal of Research in Science, Mathematics and Technology Education, 6*(2), 41-64. https://doi.org/10.31756/jrsmte.621

Wilson, D., Jones, D., Bocell, F., Crawford, J., Kim, M. J., Veilleux, N., Floyd-Smith, T., Bates, R., & Plett, M. (2015). Belonging and academic engagement among undergraduate STEM students: A multi-institutional study. *Research in Higher Education, 56*, 750-766. https://doi.org/10.1007/s11162-015-9367-x

Wu, Z., Spreckelsen, T. F., & Cohen, G. (2021). A meta-analysis of the effect of values affirmation on academic achievement. *Journal of Social Issues, 77*(3), 702-750. https://doi.org/10.1111/josi.12415

Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist*, 47(4), 302-314. https://doi.org/10.1080/00461520.2012.722805

Zumbrunn, S., McKim, C., Buhs, E., & Hawley, L. R. (2014). Support, belonging, motivation, and engagement in the college classroom: A mixed method study. *Instructional Science, 42*(5), 661-684. https://doi.org/10.1007/s11251-014-9310-0

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