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Course-Based Undergraduate Research Experiences' Influence on STEM Belonging

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Abstract

Course-Based Undergraduate Research Experiences (CUREs) offer scalable opportunities for undergraduate students to engage in authentic scientific research, with prior studies suggesting their potential to enhance STEM retention and foster a sense of belonging. This study examines the effects of CUREs on STEM belonging among students at a Hispanic-Serving Institution, focusing on the moderating influence of demographic variables such as ethnicity, gender, financial aid status, and first-generation college status. Using a pre- and post-intervention survey with 115 participants across four health sciences courses, we measured belonging in STEM subfields (science, technology, engineering, and math) using the Student Attitudes Toward Science, Technology, Engineering, and Math (S-STEM) scale.

Results revealed significant increases in engineering/technology ($t(114) = -5.88$, $p < .001$) following the CUREs intervention. There was notable interaction between Hispanic/Latino ethnicity and math belonging. Non-Hispanic/Latino students reported a statistically significant increase in math belonging, while Hispanic/Latino students, despite higher

initial scores, showed no significant change ($F(1, 84) = 6.74$, $p = .011$, $\eta^2 = .074$). These findings underscore the complexity of fostering belonging in STEM, particularly for historically minoritized groups.

This study highlights limitations in instrument design, the need for longitudinal data, and the importance of culturally tailored interventions to enhance STEM belonging. Future research should explore qualitative approaches and alternative measures, such as the Persistence in the Sciences (PITS) survey, to capture nuanced experiences and better align with psychosocial dimensions of belonging. The findings contribute to understanding how CUREs can be optimized to support diverse student populations and promote equity in STEM fields.

Keywords: course based undergraduate research experience; STEM belonging; underrepresented students in STEM; Hispanic serving institution; benefit of undergraduate research experience

Resumen

Las Experiencias de Investigación de Pregrado Basadas en Cursos (CUREs) ofrecen oportunidades escalables para que estudiantes universitarios participen en investigaciones científicas auténticas, y estudios previos sugieren su potencial para mejorar la retención en STEM y fomentar el sentido de pertenencia. Este estudio examina los efectos de las CUREs en el sentido de pertenencia en STEM entre estudiantes de una Institución al Servicio de los Hispanos, con un enfoque en la influencia moderadora de variables demográficas como la

etnicidad, el género, el estatus de ayuda financiera y la condición de ser estudiante universitario de primera generación.

Utilizando una encuesta antes y después de la intervención con 115 participantes en cuatro cursos de ciencias de la salud, medimos el sentido de pertenencia en las subdisciplinas STEM (ciencia, tecnología, ingeniería y matemáticas) utilizando la escala de Actitudes Estudiantiles hacia Ciencia, Tecnología, Ingeniería y Matemáticas (S-STEM).

Los resultados revelaron aumentos significativos en ingeniería/tecnología ($t(114) = -5.88$, $p < .001$) después de la intervención de CUREs. Se observó una interacción significativa entre la etnicidad hispana/latina y el sentido de pertenencia en matemáticas. Los estudiantes no hispanos/latinos reportaron un aumento estadísticamente significativo en la pertenencia en matemáticas, mientras que los estudiantes hispanos/latinos, a pesar de tener puntuaciones iniciales más altas, no mostraron un cambio significativo ($F(1, 84) = 6.74$, $p = .011$, $\eta^2 = .074$). Estos hallazgos subrayan la complejidad de fomentar el sentido de pertenencia en STEM, especialmente entre grupos históricamente marginados.

Este estudio destaca limitaciones en el diseño del instrumento, la necesidad de datos longitudinales y la importancia de intervenciones culturalmente adaptadas para mejorar la pertenencia en STEM. Las investigaciones futuras deberían explorar enfoques cualitativos y medidas alternativas, como la encuesta de Persistencia en las Ciencias (PITS), para captar experiencias más matizadas y alinearse mejor con las dimensiones psicosociales de la pertenencia. Estos hallazgos contribuyen a comprender cómo optimizar las CUREs para apoyar a poblaciones estudiantiles diversas y promover la equidad en los campos de STEM.

Palabras claves: Experiencia de Investigación de Pregrado Integrada en el Curso; Sentido de Pertenencia en STEM; Estudiantes Subrepresentados en STEM; Institución al Servicio de los Hispanos; Beneficio de la Experiencia de Investigación en Pregrado

Course-Based Undergraduate Research Experiences' Influence on STEM Belonging

Course-Based Undergraduate Research Experiences (CUREs) have emerged as a transformative approach to engaging undergraduate students in scientific research. Unlike traditional laboratory experiences, CUREs integrate authentic research opportunities directly into course curricula, enabling students to actively participate in research processes such as generating hypotheses, collecting and analyzing data, and presenting findings (Auchincloss et al., 2014). These experiences foster a sense of community and belonging, which have been shown to significantly enhance retention and graduation rates, particularly among underrepresented and minoritized students in STEM fields (Abrica et al., 2024). By addressing the barriers that hinder the development of science identity and self-efficacy, CUREs have the potential to reshape the educational landscape for STEM students.

Belonging plays a pivotal role in students' academic and personal success. Research indicates that a strong sense of belonging positively influences psychological well-being, academic achievement, and resilience, especially for students navigating the chilly climate often associated with STEM fields (Bae et al., 2022; Abrica et al., 2024). This study seeks to explore the impact of CUREs on undergraduate students' sense of belonging in STEM, with a particular focus on the moderating effects of demographic and social variables such as gender, race and ethnicity, financial aid status, and first-generation college status.

Through this investigation, we aim to contribute to the growing body of literature on inclusive educational practices that promote equity and representation in STEM disciplines.

Sense of Belonging and CUREs

A sense of belonging is a basic human need. Belonging is often a vital component to undergraduate students' resiliency and persistence, happiness and post-graduation accomplishments. When a student can feel they belong within a defined group, like their chosen major, research has shown an increase in their psychological well-being and academic achievement, as well as their retention and graduation rates (OUE Research, 2023). As Abrica et. al. (2024, p. 23) point out, "…a sense of belonging refers to a sense of feeling accepted, valued, and included in the learning environment.". Additionally, for students in science, technology, engineering and mathematics (STEM) field, research has found that these psychological factors can positively impact their post-graduate world by enhancing their career success, growth and future leadership capabilities and opportunities (Abrica et al.).

CUREs provide undergraduate students a unique opportunity to engage in and find their belonging in research. When CUREs are integrated into STEM curricula, students' psychosocial factors like belonging, and self-reported mental well-being improves (along with retention and graduation rates; OUE Research, 2023). Ballen et al. (2018, p. 1515) describe, "CUREs are scalable research experiences capable of engaging large numbers of students by involving the entire population of a course in a research question within the context of the course itself." CUREs provide students who would not otherwise participate in more traditional research (like non-biology major students) an opportunity to gain priceless experiences while also meeting course requirements (Burmeister et al., 2023).

Additionally, and due to their design, "CUREs can vary in duration, setting, extent of mentoring, and cost depending upon the logistical restraints of the institution." (Ballen et al., p. 1515)

By implementing the research or inquiry activities directly into the course, each student's participation increases as does their sense of community and belonging. Abrica et al. (2024, p. 23) emphasizes that "CURES therefore increase access to research opportunities for students, especially historically minoritized groups, which is an additional motivating factor for incorporating CURES into the college experience." As such, we will explore two themes in this study; first, do undergraduate students report an improved sense of belonging post CUREs experience, and second, do demographic and social variables (i.e, gender, race and ethnicity, income status, financial aid needs, first-generation status, and prior exposure to STEM) moderate the relationship between CUREs and belonging to STEM.

Previously, the environment in STEM has been described as *chilly* by underrepresented or minoritized students, therefore negatively impacting representation, identification and community. As students who did not *see* themselves represented, did not join or sustain in STEM (Abrica et al., 2024). Abrica et al. (p. 23) adds, "Decades of STEM education literature identify science identity, building self-efficacy and sense of belonging as being critical to STEM success outcomes (broadly defined as persistence, degree completion and retention) but often not sufficiently or equitably nurtured in the STEM learning context." This is where Strayhorn says CUREs can have a positive impact by increasing belonging among racialized or other minoritized groups, "particularly when thinking about STEM college students," (Bae et al., 2023).

Beyond belonging, another important component of student success in STEM, is science identity. Science identity broadly refers to "the degree one sees oneself and is recognized by others, as a "science person." Science identity includes internal processes, such as an interest in science and motivation to pursue a career in STEM disciplines," (Abrica et al. 2024, p. 23) CURES provide students the opportunity to improve their sense of identity and belonging through socialization experiences that keep them integrated in and nurtured within STEM. As Abrica et al. (2024) points out, there are often very few opportunities in the first few years of STEM students undergraduate coursework to build this sense of community through shared research opportunities (Auchincloss et al., 2014). Moreover, Abrica et al. (2024, p. 23). explains "in the absence of relevancy of course material, feelings of community, and opportunities to establish efficacy and identify, new college students who otherwise wish to pursue STEM studies may turn to other fields of study."

Furthermore, a sense of belonging, can foster retention, and "positively influence motivation, academic achievement, and well-being among" among STEM students (Dost, 2024). Belonging, self-efficacy and science identity is important in shaping STEM students commitment, interest, retention and degree completion (Abrica et al., 2024). Among racially and ethnically marginalized student populations, CUREs provide a critical opportunity to increase their ability to see themselves as a researcher (Abrica et al.). By integrating interventions that nurture psychosocial development (specifically belonging), as well as immersion in community-based research activities, STEM students have reported "substantive and meaningful differences in the lives of students," (Abrica et al.).

On the other hand, a lowered sense of belonging has been shown to adversely impact one's resiliency, and persistence within STEM field, and notes that most of who experience these negative feelings are female and minoritized students (Dost, 2024). CUREs have been shown to dramatically improve such feelings by providing "authentic" research experiences that allow students, even those in entry-level courses, to have hands-on engagement with course material (Abrica et al., 2024, p. 23). More importantly, CUREs have been shown to have an impact on knowledge acquisition and psychosocial outcomes thus improving persistence and retention rates among students (Abrica et al.). Equally important, CUREs are different from traditional laboratory experiences, by requiring a cohort of students to perform the scientific research process together, thus fostering a sense of belonging and community and increasing project ownership (Buchanan et al., 2022). This in turn has been linked to a greater degree of persistence and representation among underrepresented STEM students (Hispanic/Latinx populations) by enhancing retention and development of psychosocial traits (Abrica et al).

Additionally, "the most successful interventions are those which integrate collaboration, mentoring relationships, and critical thinking," (Abrica et al., 2024). Among minoritized students, a community-oriented learning environment can promote one's science identity, self-efficacy and sense of belonging, while also providing validation of students' backgrounds (Abrica et al). Because of this, students have reported they do not feel "forced to assimilate to white norms and values traditionally upheld in STEM environments. Community-based and culturally engaging STEM learning environments embrace students' cultural values and are reflective of the communities they are a part of," according to Abrica et al.

According to Auchincloss and colleagues (2014, p. 30), there are five core components linked to CUREs, including: (1) Use of scientific practices, where students participate in activities ranging from asking, questions to proposing and designing studies to analyzing and evaluating data and models; (2) Discovery, which pushes students to gain new knowledge or insight; (3) Broadly relevant or important work, which students can develop and strengthen their contribution to current research and knowledge; (4) Collaboration, which students can work with fellow classmates and the instructor to address, solve and provide feedback in addressing complex issues and interpreting results during the CUREs procedure; and (5) Iteration, in which students must continue to build upon their knowledge and repeat or revise to address problems or inconsistencies, rule out alternative explanations, gather additional data to support assertions or modify when things go awry. Additionally, it is theorized that "participation in a CURE with these activities will lead to student outcomes such as development of technical skills self-efficacy, scientific aspirations, science identity, and science expertise," (Auchinloss et al., 2014, p. 31).

Based on this initial logic model, Corwin et al. (2015) proposed a more inclusive framework to explain the potential relationship between student outcomes in relation to exposure to CUREs and psychosocial factors felt in their major. Corwin et al. (p. 14) explain, "This model features specific components of CUREs such as collection of novel data, investigation of the primary literature, student collaboration, dissemination of work outside class, and project design." Then, they hypothesized relationships between student outcomes and these specific components of CUREs, which can include activities that fall under the broad umbrella of scientific practices (Corwin et al.). The goal of this advanced

model was to "predict relationships that could then be rigorously examined. However, there has been limited research investigat-ing these relationships. Some authors have indicated that stu-dents report positive shifts in their self-determination, self-efficacy, and overall motivation in a CURE as compared with a traditional laboratory experience," (Corwin et al., p. 14) Additionally, another study found that "discovery, iteration, and collaboration in a CURE have a positive impact on student own-ership and career goals," (Corwin et al). Furthermore, an important component of this conceptual model working is the relationship between student and faculty. Being that student engagement can be dramatically impacted by the frequency and nature of the relationship with the leading faculty (Abrica et al., 2024). This implies that "student interactions will enrich the college experience and facilitate success," (Abrica et al., p. 23).

However, research emphasizes that "racial stress creates an additional cognitive load for minoritized students where they must constantly reassess and reappraise their identity, values, beliefs, and ways of being with respect to white norms and values," (Abrica et al., 2024, p. 23). Empirical studies continue to argue that learning environments can be designed to support diverse student population by increasing representation in the research process. This would specifically improve a sense of belonging among Latina/o/x students by giving them the opportunity to see themselves (and their peers) as *researchers* (Buchanan et al., 2022). Nevertheless, "if those frequent interactions consistently send signals to students their cultural identities are devalued, they are second-class citizens, or the faculty member does not care about their success, such experiences might not have a positive influence on the college experience or success at all," (Abrica et al., 2024, p. 23). As such, frameworks that consider the qualitative aspects of students' environments

including the activities they engage in, the experiences they are immersed in, and their overall participation are warranted (Abrica et al.). When these factors are addressed, and equal representation is achieved, research shows students' have significantly improved outcomes, including graduation with a STEM degree (OUE Research, 2023). This in turn has been shown to "reduce income equity gaps as STEM jobs are projected to grow faster, provide greater earning potential, and produce lower rates of unemployment than non-STEM jobs over the next decade," (OUE Research).

Likewise, it is suggested that more research is needed to fully understand how belonging is felt among the more underrepresented student, and how financial aid and generation status plays a part in one's self-reported view of belonging in the STEM field (Dost, 2024). In addition to trends in STEM majors, it is important to understand (more deeply) how CUREs mediate students' decisions to stay in STEM and the importance these motivational factors with participation in CUREs plays for such students outside of science-based studies, as "CUREs research has been disproportionally published on a small number of CUREs on a narrow range of biology, mainly large CUREs in the wet lab-based microbial sciences," (Burmeister et al., 2023).

Methods

Prior to beginning this study, it was approved by the California State University Channel Islands Institutional Review Board.

The Intervention: CUREs

To implement a CUREs opportunity in different undergraduate health sciences courses, a required research project was developed for each respective course. The projects focused on students contributing to an original research project, whether it was an existing

project of the instructor or one the student selected. Depending on the specific course, students focused on generating research questions and hypotheses, designing an experiment, collecting data, analyzing data, and/or presenting results at the university's student research conference. In two of the four courses, virtual reality technology was used as a part of the CURE intervention emphasizing an engineering, technology angle to those CUREs.

Sampling Methods

Convenience sampling from four undergraduate health sciences courses at a Hispanic Serving Institution in Southern California were used for this study. The classes were titled Health Law, Healthy Aging, Health Science Research Methods, and Community Health. All registered students were asked to participate in the study - the classes had an enrollment of 30, 29, 28, and 38, respectively. Students were not offered any extra credit for participating in this study, but their original research project was a requirement for the course.

Data Collection Methods

A pre- and post-CURES intervention online survey was gathered with students during the first two weeks of the semester and the last two weeks of the semester after completion of the CUREs intervention. An informed consent was included in the pre-survey. Students were given the option to opt out of the study but still participate fully in the class without penalty. No students opted out. Demographic information and a STEM belonging scale were included on the survey. The Student Attitudes Toward Science, Technology, Engineering, and Math (S-STEM) was used to measure STEM belonging (Unfried, et al., 2015). This scale was chosen, because it had face validity, internal

consistency reliability (Cronbach's alpha = .83-.87), and provided separate sub-scales for STEM belonging in science, technology/engineering, and math. The scale ranged from 1-5 with response options with coding as follows: Strongly disagree (1), disagree (2), neutral (3), agree (4), or strongly agree (5). Higher subscale scores indicated more STEM belonging in that sub-STEM field. Example items included: I would consider choosing a career that uses math, I expect to use science when I get out of school, If I learn engineering, then I can improve things people use every day, and I am curious about how electronics work.

Analytical Methods

Descriptive statistics were reported on each demographic and key variable. To prepare for hypothesis testing, a power analysis conducted by G*Power for a repeated measures ANOVA with p = .80 determined that the sample size needed was 34. Bivariate analyses were conducted on all independent variables and dependent variables to assess relationships. Only those variables with statistically significant relationships in bivariate analyses were included in the final repeated measures ANOVA models.

Results

Descriptive Statistics

The sample for this study consisted of 115 undergraduate students (Table 1). The average age was 23, older than average for undergraduate students. The sample was predominantly female. The racial composition was diverse, with the majority being White followed by those identifying as another race. Additionally, most students identified as Hispanic or Latino.

Table 1

Description of the Sample (N = 115)

	Mean(SD)	Frequency(%)
Age	23.01(6.65)	
Biological Sex at Birth		
Female		91(79.1)
Male		24(20.9)
Gender Identity		
Female/Woman/She/Her		86(74.78)
Man/Male		29(25.21)
Race		
White		59(51.3)
Other Race		27(23.5)
Asian		14(12.2)
Black or African American		7(6.1)
Two or More Races		7(6.1)
American Indian or Alaska Native		1(0.9)
Hispanic or Latino		
Yes		71(61.7)
No		42(36.5)
First Generation College Student		
Yes		76(66.1)
No		39(33.9)
Qualify for Financial Aid		
Yes		81(70.4)

	Mean(SD)	Frequency(%)
No		34(29.6)
Employed Other Unemployed Part Time Full Time		 2(1.7) 24(19.1) 76(66.1) 15(13.0)
Had close friends with careers in or are going to school for STEM		62(53.9)
Had close family with careers in or are going to school for STEM		81(70.4)

In terms of socioeconomic status, most participants were first-generation college students, and three-fourths qualified for financial aid. Employment status varied, with the majority working part-time. Additionally, more than half of participants had close friends and most had family members in STEM fields.

Inferential Statistics

Paired Samples T-Test

Table 2 shows the paired samples t-test results for pre- and post-assessments of students' sense of belonging in STEM fields. The analysis did not reveal significant changes in most of the scales except for Math and Engineering/Technology. The Math belonging scores increased slightly from a mean of 3.18 (SD = 0.75) to 3.25 (SD = 0.73), which was statistically significant ($t(114) = -1.58$, $p = .05$). The largest change was seen in

the Engineering/Technology belonging scores, which increased significantly from 2.86 (SD = 0.63) to 3.14 (SD = 0.74) ($t(114) = -5.88$, $p < .001$).

Table 2

Belonging to STEM Scales Pre and Post- Paired Mean Comparison (N = 114)

	Pre	Post	*t*(*p*)
I belong in STEM	4.32(.84)	4.37(.85)	-.67(.25)
I'm confidence in my STEM abilities	4.16(.74)	4.21(.91)	-.71(.23)
Math	3.18(.75)	3.25(.73)	-1.58(.05)*
Science	4.11(.65)	4.14(.74)	-.72(.23)
Engineering/Technology	2.86(.63)	3.14(.74)	-5.88(.001)*
21st Century Skills	4.43(.44)	4.44(.48)	-.34(.36)

*All items or scales ranged from 1-5 with 5 meaning more confidence or belonging.

Repeated Measures ANOVA

The repeated measures ANOVA results for the impact of CUREs and demographic factors on students' sense of belonging in STEM are presented in Tables 3 and 4.

Engineering/Technology Belonging. The main effect of CUREs was significant ($F(1, 86) = 13.05$, $p = .001$, $\eta^2 = .15$), indicating a significant increase in belonging to Engineering/Technology careers post-CURE. No significant interaction effects were found with demographic factors.

Math Belonging. There was no significant main effect of CUREs on Math belonging ($F(1, 84) = 0.579$, $p = .44$, $\eta^2 = .007$). However, there was a significant interaction with Hispanic/Latino status ($F(1, 84) = 6.74$, $p = .011$, $\eta^2 = .074$), suggesting that a change in sense of belonging in Math careers before and after CUREs was significantly influenced by Hispanic/Latino status.

Table 3

Repeated measures ANOVA Results for Effect of CUREs and Demographics on Belonging to Engineering/Technology Career

	SS	df	MS	F	p	η^2
CURE	1.35	1	1.35	13.05	.001*	.15
CURE*Hispanic/Latino	.004	1	.004	.03	.84	.001
CURE*FinancialAid	.156	1	.156	1.51	.22	.020
CURE*FriendsinSTEM	.004	1	.004	.042	.83	.001
CURE*Female	.026	1	.026	.253	.61	.003
CURE*FamilyinSTEM	.057	1	.057	0.55	.46	.008
CURE*Firstgeneration	.049	1	.049	.47	.49	.006
Error	9.10	86	.106			

Note. SS = Sum of Squares; df = Degrees of Freedom; MS = Mean Square; F = F-value; p = p-value; η^2 = Eta Squared; * = $p < .05$; First generation status, gender, financial aid, Hispanic/Latino, friend, family had bivariate statistically significant differences between and pre and post math belonging thus were included in the model.

Table 4

Repeated measures ANOVA Results for Effect of CUREs and Demographics on Belonging to Math Career

	SS	df	MS	F	p	η^2
CURE	.065	1	.065	.579	.44	.007
Hispanic/Latino	.762	1	.762	6.74	.011*	.074
First generation	.043	1	.043	.383	.538	.005
Financial Aid	.001	1	.001	.009	.923	.000
Friends in STEM	.000	1	.000	.001	.971	.000
Female	.028	1	.028	.250	.619	.003
Error	9.48	84	.113			

Note. SS = Sum of Squares; df = Degrees of Freedom; MS = Mean Square; F = F-value; p = p-value; η^2 = Eta Squared; * = $p < .05$; First generation status, gender, financial aid, Hispanic/Latino and having a friend in STEM had bivariate statistically significant differences between and pre and post math belonging thus were included in the model.

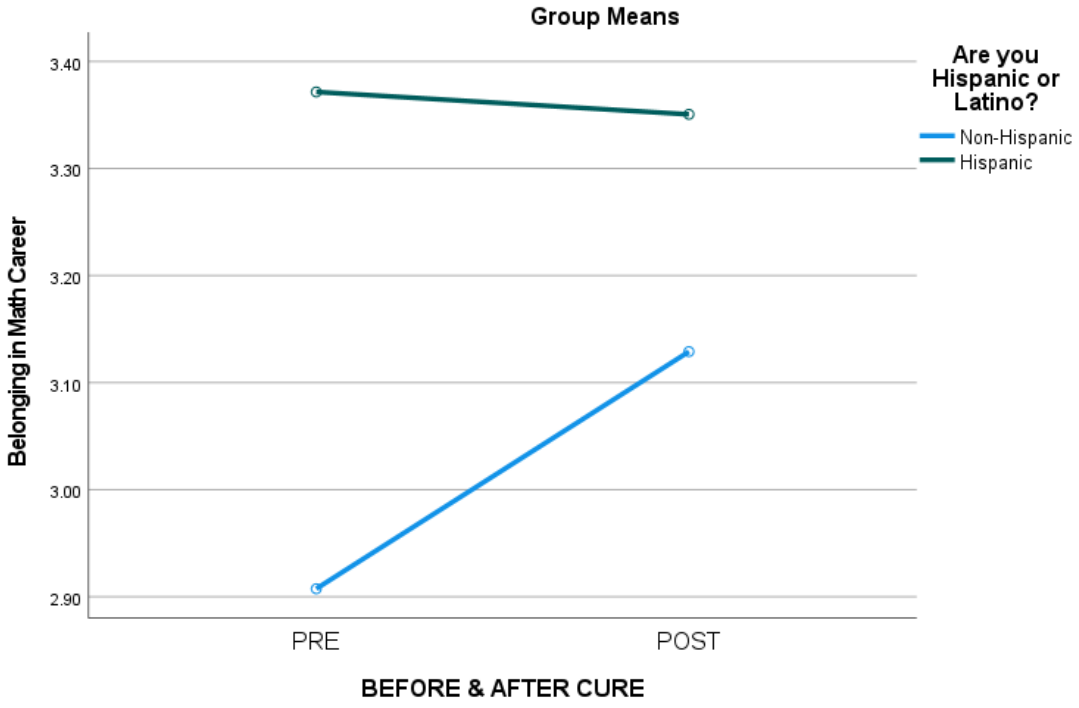
Visual Data Presentation

Figure 1 illustrates the differences in pre- and post-intervention belonging scores between Hispanic/Latino students and non-Hispanic/Latino students. The figure shows that

non-Hispanic/Latino students experienced a greater increase in their sense of belonging in STEM fields compared to their Hispanic/Latino peers, aligning with the significant interaction effects found in the repeated measures ANOVA for Math belonging. The non-Hispanic/Latino peers (M = 3.02, SD = .80) had statistically significantly lower math career-belonging than their Hispanic/Latino peers (M = 3.28, SD = .70) at the pre-test (t = -1.79, p = .03). While the Hispanic/Latino students stayed relatively the same before and after the CURE, non-Hispanic students felt a stronger sense of belonging after the CURE but this groups' mean remained slightly lower than Hispanic students still.

Figure 1

Differences in Pre and Post Means among Hispanic/Latino Students and non-Hispanic/Latino Students in Math Belonging



Note. This figure shows a statistically significant increase of the pre- and post-scores of non-Hispanic students from an average of 2.91 to 3.13. There is an observed very slight visual decrease in pre- and post-scores among Hispanic students, but there was not a statistically significant decrease. Hispanic students went from an average score of 3.37 to 3.35.

Discussion

While a significant change in a sense of belonging in STEM, confidence in STEM abilities, belonging in science, and 21st century skills was not observed in this study, it found a statistically significant difference in a sense of belonging within engineering/technology and math. Additionally, there was a Hispanic/Latino ethnicity statistically significant interaction with their sense of math belonging following the CUREs implementation. The results indicated that those who were Hispanic/Latino did not have statistically significant changes in math belonging while those who were not Hispanic/Latino did. Hispanic/Latino students had statistically significantly higher pre-CURES math belonging scores than non-Hispanic/Latino students. Hispanic students' average pre-score was 3.37 though so they still had more room to increase their score in the post-test but not as much as the non-Hispanic students' pre-score, which was 2.91. Thus, the results indicate complexity when interpreting the results of the initial hypothesis that undergraduate students will report statistically significant improvements in their sense of belonging in STEM before and after a CUREs. The data does partially support the second hypothesis that race and ethnicity influence the relationship between the CUREs and a sense of belonging.

These results build on existing research in relation to the impact of CUREs on undergraduate students. Literature indicates that CUREs can be used to increase a sense of belonging which influences STEM retention (Hanauer et al., 2016; Bradshaw et al., 2023; American Association for the Advancement of Science, 2023). Hanauer et al. (2016) note that psychological self-understanding from educational experience influences students' retention rates in STEM courses. Specifically, course research experiences directly influence self-efficacy, self-identity, scientific community values, and networking which influence the intent to stay in science (Hanauer et al., 2016). In 2022, The National Student Clearinghouse Research Center (2024) reported that retention rate for health-related majors was 77.1% with over 10% of students transferring out of a health-related degree. Furthermore, engineering had a transfer out rate of 6.4%, and biology and biological sciences had a transfer out rate of 9.5% (National Student Clearinghouse Research Center, 2024). CUREs have been shown to improve retention rates in STEM fields (Bradshaw et al., 2023). CUREs are considered effective ways of introducing a large portion of students to research, which can help increase retention rates, especially in populations who are historically excluded (Bradshaw et al., 2023). In contrast, results from this study do not align with the broader body of literature that supports a strong correlation between CUREs implementation and an increased sense of belonging and persistence in STEM (Abrica et al., 2024; Hanauer et al., 2016). There are several limitations and considerations that may contribute to this gap.

It is important to consider the instrument utilized in each of the previously mentioned studies in comparison to this study. This study utilized The Measure of Student Attitudes Toward Science, Technology, Engineering, and Math (S-STEM) by Unfried et al.

(2015). This instrument was originally validated for two age ranges within the K-12 age bracket and questions were phrased in a manner that would be appropriate for their reading level. The instrument's goal was to assess career interests. Although this instrument aligns with this study's goal and hypotheses, it should be noted that the basis of this survey focuses on the larger theory of career development within social cognitive career theory (Unfried et al., 2015). Therefore, other instruments may align more with the psychosocial elements to belonging, retention, and the experience of students who are historically minoritized in STEM.

Data suggests that STEM students' demographics and background influence their experience in STEM (American Association for the Advancement of Science, 2023). Undergraduate research is one of several strategies aimed at enhancing nontraditional students' sense of belonging in science, yet no single approach is effective at reaching all students, and the most successful interventions have included a combination of mentoring, research, career exploration, and personal connection (American Association for the Advancement of Science, 2023). Thus, a potential limitation to this study is not tracking students' exposure to other forms of STEM engagement that facilitate belonging as confounding variables. Additionally, one of the CURES used a virtual reality scenario with a story of a Latina woman. Future research may explore the potential impact of specifically culturally-relevant CUREs for Hispanic students. Some students in this study were enrolled in multiple CUREs classes at once or have engaged in other forms of academic mentorship and research.

Furthermore, this study only measures students' sense of belonging during one semester and does not account for longitudinal data reflecting their STEM journey and belonging throughout their academic career. Additionally, this study does not stratify data by upper and lower division students. This is a potential limitation because research indicates that early introduction to CUREs, specifically in students' freshman year, significantly enhances students' likelihood to graduate with a STEM degree within six years (Rodenbusch et al., 2016). Therefore, further considerations for the timing of the CUREs project should be considered.

Future recommendations for this study would be to include a qualitative analysis to help identify nuanced experiences with belonging in STEM. In a systematic review conducted by Dias-Broens et al. (2024), the review revealed that there is often a misalignment between definitions and measurements when it comes to a sense of belonging. Qualitative thematic coding would allow for student driven themes to emerge on their sense of belonging. Future iterations of this study could consider the value of an instrument like the Persistence in the Sciences (PITS) assessment survey since it measures project ownership, self-efficacy, science identity, scientific community values, and networking which may illuminate a broader understanding of how CUREs involvement specifically correlates to different dynamics of belonging in STEM (Hanauer et al., 2017).

Conclusion

This study contributes to the ongoing exploration of course-based undergraduate research experiences (CUREs) and their impact on STEM students' sense of belonging. While significant changes in a broad sense of STEM belonging were not observed, the

study identified meaningful differences in belonging within engineering/technology and math, with nuanced interactions between Hispanic/Latino ethnicity and math belonging. These findings underscore the complexity of measuring and interpreting the effects of CUREs, particularly when considering the demographic and cultural diversity of students. The results partially support the hypothesis that race and ethnicity influence the relationship between CUREs and belonging, highlighting the importance of culturally relevant approaches in educational interventions.

Despite its alignment with existing literature that emphasizes the value of CUREs in enhancing STEM retention, this study reveals limitations in instrument selection, measurement focus, and the breadth of contextual factors. The use of the S-STEM survey, designed primarily for career interest assessment, may not fully capture the psychosocial dimensions of belonging critical to minoritized students' experiences. Furthermore, the lack of longitudinal data and stratification by academic level limits the understanding of belonging's evolution across students' STEM journeys.

Future research should incorporate qualitative methods to capture the depth and nuance of students' experiences, explore culturally tailored CUREs, and adopt instruments like the Persistence in the Sciences (PITS) survey to address the multifaceted nature of belonging. Addressing these gaps will enhance the understanding of how CUREs can be optimized to support diverse student populations, further solidifying their role as a vital strategy for fostering inclusivity and retention in STEM fields.

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