Increasing Sense of Belonging for Low-Income Engineering Students: A Review of Barriers, S-STEM Programs, and Future Directions

Ms. Anya Work, Virginia Polytechnic Institute and State University

Anya Work is part-time doctoral student in Virginia Tech's Higher Education program and currently serves as an assistant director in Virginia Tech's Career and Professional Development office where she works with engineering and computing students. Her research primarily focuses on the role of institutional agents in supporting low-income engineering students.

Increasing Sense of Belonging for Low-Income Engineering Students: A Review of Barriers, S-STEM Programs, and Future Directions

Introduction

Obtaining a postsecondary degree is associated with positive gains for graduates, including increased earnings, higher levels of employment, and better health [1][2]. An increase in earnings levels aids in working against equity issues in education and society. For example, college graduates earn on average $24,900 more than high school graduates [1]. Although there are positive outcomes for low-income students (LIS) who obtain a college degree, this student population continues to struggle with higher education access and retention. Institutions contribute to the continuation of institutional classism, defined as students' exclusion from activities or opportunities and identity-based discrimination [3], in admissions criteria, policies, and programming [4][5][6][7][8][9]. LIS may desire to attend a higher education institution, however access barriers, including lack of access to extracurricular activities before college, amount of financial aid, and institutions' reliance on standardized tests prevent them from attending their preferred choice or attending all together [6].

Within engineering, there have been calls to diversify programs, leading to professional development opportunities and targeted support for marginalized student populations in engineering, often focusing on women and racially minoritized populations. However, socioeconomic status is frequently absent in conversations on access and success in engineering [10]. Engineering serves as an opportunity for upward mobility for low-income engineering students, as well as an opportunity for LIS to bring diverse perspectives to solve engineering problems [11][12]. However, in the pursuit of an engineering degree, high-income students are five times more likely than LIS to graduate within six years [13].

Within education, researchers link sense of belonging to a variety of significant student outcomes including retention, persistence, major choice, and career path [14][15][16]. Sense of belonging has previously been defined as the "experience of personal involvement and integration within a system or environment to the extent that a person feels they play a special role in that system or environment" [17]. Belonging affects an individual's beliefs and behavior, including engagement, academic outcomes, and mental wellbeing [18].When a student feels like they belong, their increased engagement leads to an effort to make friends, prepare for classes, join student organizations, and pursue support [16]. Students with a higher sense of belonging tend to have more confidence in their academic life and generally enjoy their college experience [19]. Students with lower levels of belonging are associated with low levels of motivation and academic outcomes as well as feelings of isolation [20].

While the literature on the belonging experiences of low-income engineering students is sparse, the National Science Foundation (NSF) Scholarships in Science, Technology, Engineering, and Mathematics Program (S-STEMs) frequently utilizes sense of belonging as a programmatic outcome. The structure of these programs varies based on institution, however common components include bridge programming, peer and faculty mentoring, research opportunities, and career development workshops. In addition to exploring barriers for LIS and the components and outcomes of S-STEM programs related to sense of belonging, this review suggests action items for institutional and departmental leadership to scale up S-STEM interventions to address structural inequities for low-income engineering students.

Challenges to Belonging

Before delving into the interventions S-STEM provides to support the sense of belonging and ultimately persistence of low-income engineering students, it is important to discuss institutional classism's effect on LIS' feelings of belonging in higher education [3][35][33][39]. Understanding the root of an issue enables institutional leaders to make more thoughtful changes. LIS are more likely than their high-income peers to have work or family responsibilities, which may mean less time for schoolwork or engagement opportunities [7][12]. In addition to work and family responsibilities, LIS may focus more on concerns around tuition and housing and food insecurity, which outweighs the desire to engage and increase their sense of belonging [34]. LIS can also feel like an outsider when they are unable to afford required and supplemental materials, or the expensive fees associated with STEM majors [25]. When students' on and off campus opportunities are limited based on finances, students may also believe their post-graduation plans are limited and experience academic and social dissatisfaction [3]. One study [33] found educational institutions view White and middle class as the norm, and students who are unfamiliar with structural inequities that cause differences in experiences may internalize challenges and make them feel alienated. LIS may not have people in their lives to help build social capital that can be crucial for success [33]. They may be unaware of internship and job opportunities, who to turn to for support, or how to communicate with faculty, who can often serve as connectors to opportunities [33]. Students with multiple marginalized identities, such as being low-income and identifying with a racially minoritized population, experience compounded inequities [3][15][26][35].

Factors Supporting Belonging

Although LIS experience many challenges in higher education, there are several proven practices that encourage LIS belonging [15][22][23][27][29]. These practices include need-based programs, identity-based student organizations, positive interactions with faculty, and high-impact practices including study abroad and opportunities to blend academic and career interests through internships, student organizations, and research opportunities [15][27][29]. When LIS are members of need-based support programs they experience increased belonging because they have opportunities to build community with students from similar backgrounds [27]. Students also have opportunities to build relationships with program staff and learn important practices to help them succeed, such as the significance of connecting with faculty outside of the classroom, utilizing office hours, and pursuing research opportunities. However, LIS may not have access to high-impact engagement opportunities that could support their success based on time and finances [7][30][33].

Inequities in Engineering

Although an engineering degree can serve as an upward mobility opportunity for LIS, this student population faces additional challenges due to the culture of many engineering programs. LIS may not have access to Advanced Placement (AP) courses, such as math and science, that benefit students as they navigate "weed out" courses in engineering programs [12][35]. The culture of engineering programs often focuses on individualist goals and technical innovation, which are historically aligned with the values of White, middle-class men [15][25][31]. These values often clash with those of marginalized students, including LIS who view engineering as

an opportunity to collaborate with their communities to solve issues [31]. Previous research also shows a correlation between the number of hours worked and the likelihood of remaining in a STEM degree program, which negatively impacts LIS at higher rates when compared to their wealthier peers [31]. Lastly, low-income engineering students may not feel like they fit in, as engineering faculty often gravitate towards students who have similar identities, leaving low-income engineering students to feel as though their experiences are not valued [12][33].

Intersections of Identity

A critique of the literature on LIS is a lack of focus on the intersections of students' identities such as race, ethnicity, and gender. Challenges to a LIS' sense of belonging are exacerbated when they have multiple marginalized identities [15][16][24][27][28][30][37]. For example, low-income students of color experience "lower rates of graduation, prolonged time to degree, and lower grade point averages" [36]. If a student feels they fall outside of the dominant identities of an institution or department or are made to feel as though they do not fit in, their sense of belonging suffers [16]. In a study exploring the relationship between sense of belonging and intersectionality for STEM and non-STEM students, students with racially minoritized identities and women felt like outsiders due to the homogeneity of their peers and negative interactions with faculty in their departments [15]. Although it has been established LIS may experience low expectations from authority figures, these feelings are experienced at higher levels when a student is both low-income and racially minoritized [27]. However, low-income students who connected with identity-based organizations found opportunities to challenge external and internal beliefs about racism, sexism, and classism [27][37]. Another study exploring belonging in STEM and intersections of race and gender found students experienced an increase in sense of belonging if they had relationships with faculty and peers in their major, confidence and interest in a major, and a strong science identity [28]. Additionally, women and students of color who decided to leave their STEM majors experienced a lack of relationships within their department and low levels of science identity. Marginalized students in STEM also consistently report an increase in belonging when their identities are reflected in their peers, faculty, and mentors [28][34][33].

It is crucial students' sense of belonging is a focus for engineering departments as feelings of belonging within a student's department and STEM classes is shown to have a more significant impact on students' engagement and persistence than feelings of belonging at the institutional level [14][33]. A study on belonging across multiple institutions found belonging in STEM classrooms has a strong influence on student engagement regardless of institutional type [35]. In computing classes, women reported they felt like they belonged in their department when they are a part of a community, that they are supported by their peers, and that their department cares about them [32][33][34]. Although the literature on underrepresented student experiences and intersectionality in STEM has increased, a student's socioeconomic background is rarely mentioned in discussions of belonging.

S-STEMs

S-STEM programs are funded by the National Science Foundation (NSF) and were developed to increase the retention and persistence of students with financial need in STEM programs. In addition, research has been conducted about S-STEMs to understand the outcomes associated

with the program and the needs of low-income engineering students. This research tends to focus on student outcomes including retention, sense of belonging, self-efficacy, and science identity [35][38][39][40][41][42]. Students in S-STEM programs experience an increase in retention and persistence in STEM programs when compared to students with similar financial and academic backgrounds who do not participate in S-STEMs [38][41][43]. For example, Bridgewater State University's (BSU) S-STEM program, Students Engaging in Scientific and Mathematical Interdisciplinary Collaboration (SEISMIC), which was developed to support low-income science and mathematics majors, has seen an increase in retention for their SEISMIC scholars [38]. BSU's SEISMIC unique program typically includes a cohort of 8 to 11 students and courses taught by the Philosophy and Psychology departments, which plays a role in encouraging students to see how they can utilize engineering to encourage positive change in their communities. Ninety-five percent of SEISMIC Scholars from the first two cohorts graduated with a STEM degree or remained in STEM major, compared to 72% of the control group.

In addition to increasing the retention and persistence of students with financial need in STEM fields, research shows S-STEM programs increase students' sense of belonging, self-efficacy, and science and engineering identity [35][38][39][40][41][43]. Students in BSU's SEISMIC program believed participating in the program increased their technical and transferable skills, aided in developing social and cultural capital, and played a role in increasing their self-efficacy [38]. Iona College, a Catholic coeducational institution in New Rochelle, New York where 99% of students receive financial aid, has an S-STEM program, DESIRE Scholars which serves Chemistry and Computer Science students [41]. DESIRE Scholars receive a $6000 scholarship each academic year and are assigned a faculty advisor, peer mentor, participate in the Careers in Science at Iona (CSI) Program, conduct summer research with a research advisor, and enroll in tailored courses for DESIRE cohorts [41]. 22 DESIRE Scholars and 20 students from a control group were surveyed on their campus engagement. DESIRE Scholars were significantly more likely to be engaged in work study, student organizations, research projects, and professional conferences when compared to students with similar academic and financial backgrounds that were not in DESIRE. One study [35] explored components of the University of Arkansas' Path to Graduation, an S-STEM program that serves up to 36 students and is meant to increase the number of STEM students from low-income, rural backgrounds, during its first year of implementation. To be in this program students must be Pell eligible and in an engineering or physical science program. Students surveyed in the Path to Graduation program experienced an increase in sense of belonging, which was attributed to the program's bridge programming and faculty mentorship.

Research around S-STEM also surveys students on what programmatic components they believe aids in increasing engineering and science identity. One study [39] on self-efficacy and science identity included 32 S-STEM students from a variety of engineering majors at a large western land-grant university. Students believed peer mentors contributed to an increase in self-efficacy, engineering courses fostered engineering identity and building community, and opportunities to meet with faculty increased students' confidence in speaking to other faculty. Thirty-six mechanical engineering students from the University of Maryland Baltimore County's S-STEM were surveyed on the program components they felt increased their self-efficacy, science identity, and sense of belonging [43]. Scholars associated an increase in their self-efficacy and engineering identity with mentoring, research, and internships, and the community building opportunities in their program helped to increase their sense of belonging. The community

college students in one study [40] believed the faculty and staff who recommended them for the S-STEM program played a role in the development of their science and engineering identity. S-STEM students consistently associate programmatic goals, such as a sense of belonging, self-efficacy, and science identity with the relationships and support received from faculty and staff.

As previously mentioned, the interventions of S-STEMs vary across institutions, however, there appear to be several practices that have increased participants' sense of belonging. Research consistently discusses the disconnect between low-income engineering students' values and the values of engineering departments [31]. Programs such as BSU's that provide opportunities for students to connect engineering concepts to societal change move towards value alignment between low-income engineering students and their chosen fields. A belief in one's science identity also has a relationship with a student's sense of belonging, which can be supported through research opportunities with faculty and a department supportive of students with a variety of identities [25][39][43]. Research on S-STEM and belonging also echoes research on the crucial role faculty, staff, and peers play in a students' belonging. Students in S-STEMs often have opportunities to interact with faculty outside of the classroom, such as through undergraduate research. Additionally, S-STEM scholars develop community with their peers through cohort-based learning. S-STEM students also have access to high-impact practices such as internships, research, service-learning, and living-learning communities that are associated with an increase in belonging. The following interventions suggest ways to expand the reach of existing support approaches.

Interventions

Faculty & Student Belonging

The findings of this review contribute to institutional practices in several ways. Previous research consistently highlights the role faculty and staff play in a students' sense of belonging, which in turn impacts students' retention and persistence at an institution [35][38][40][43]. LIS may experience challenges accessing primary and supplemental course materials based on finances, which can cause them to fall behind and feel out of place. Engineering faculty can be intentional about selected course materials and try to choose texts available electronically through an institution's library or through open access. Faculty can be more intentional in considering the identities and experiences they center in the classroom. For example, students from low socioeconomic backgrounds may not have the same access to AP classes and engineering-related extracurricular activities as their higher income peers, and it is important faculty do not make assumptions about the knowledge students bring to the classroom. LIS also share their socioeconomic status is seen as a deficit by their institutions [12][33]. Faculty can focus more on discussing the strengths of all students in the classroom [10][33]. For example, faculty could discuss assets of students from working class backgrounds, including being hardworking, mature, and committed to giving back to their communities [33]. Faculty can also put students into teams during class. This could be an opportunity for students to connect with one another when they may have responsibilities outside of the classroom that keep them from other engagement opportunities. Additionally, previous research consistently shows the importance of value alignment for students' sense of belonging and career choice [3][44]. Both individual and communal values should be incorporated into departmental values to help students find purpose in their work [44].

Increase Access to High Impact Practices

Although focusing on how the classroom and departmental environment can change is a promising initiative as LIS may be unable to participate in extracurriculars, institutional leaders should also make an effort to provide access to those high impact practices. S-STEMs regularly incorporate undergraduate research, internships, and peer and faculty mentorships into programming to support belonging and help students build necessary skills for their fields. Institutional and departmental leadership should reflect on how they can increase student awareness of these opportunities, as many LIS are first-generation and may not have existing connections to fields that their higher-income, continuing generation peers do. Faculty and staff can serve as connectors for students between internships, undergraduate research experiences, and other on-campus opportunities to help students build community and applicable skills. LIS may believe internships and research opportunities are not an option because they have financial obligations. Faculty and staff can educate students on the paid research and internship opportunities available. Institutional leaders can also provide professional development workshops for faculty and staff that lead to more inclusive support practices, making sure to go beyond focusing on first-generation or low-income identity and incorporate intersections of identity.

Programmatic Changes

In addition to institutional changes, campus leaders can reimagine existing programs and practices to support the academic and social capital of low-income engineering students, which can lead to an increase in belonging. For example, LIS may be unaware of the support resources available to them. When institutional leaders, faculty, and staff discuss the importance of resources such as academic advising, mental health counseling, and tutoring services, LIS can increase their awareness of resources to support their success [45]. With virtual programming becoming more common since COVID, departments can provide some of these opportunities virtually to reach commuting students. Another common finding in the research on LIS is a discomfort with asking for help [29]. By normalizing support-seeking behavior, LIS can build rapport with faculty members outside of the classroom and connect to crucial support services.

Student Policies & Student Barriers

Previous research shows the drastic difference between the retention rates of students who participate in S-STEM programs, and those who do not [41][43]. These findings warrant further analysis of organizational structures that create barriers for LIS. Campus leaders can lead initiatives to analyze the policies students interact with and encourage departments to have discussions on support and pedagogical practices that aid or hinder LIS. Previous research also discusses the role of partnerships in ensuring student success, as opposed to siloed programmatic attempts at supporting marginalized students [7][10][45][46][47] Institutional leaders can explore the possibility of bringing together various stakeholders to discuss a collaborative approach to support. For example, LIS may have less time for engagement opportunities due to work and family commitments [7]. This could lead to a discussion of possible engagement opportunities that take place in the classroom in collaboration with industry partners. Additionally, future research might examine the experiences of students who do not participate

in specialized STEM programs to increase awareness of how these students navigate the cultures of their departments and institutions, and what students perceive as barriers to their success.

There are also policies that go beyond the student level that indirectly affect student belonging. Previous research on institutional change suggests reward structures at institutions, such as the tenure process, encourage faculty to focus more on research at the cost of teaching and providing additional support to students [7][46]. Additionally, underrepresented students in STEM reference the importance of sharing identities with their peers, faculty, and mentors [16][28][34]. These findings suggest a need to move towards more equity-minded hiring practices and increase the diversity of faculty within engineering programs. Analyzing policies that guide how students are supported, as well as policies that create barriers for LIS, such as STEM comprehensive fees, may lead to an increase in persistence in STEM majors for LIS. Previous research shows students' basic needs, such as food and housing, must be met before they are able to tend to other parts of their lives, including becoming more engaged [7]. By removing barriers to students' basic needs, low-income engineering students may become more engaged on campus, connect with faculty, staff, and peers, increase their sense of belonging, and ultimately their persistence to graduation.

References

[1] J. Ma, M. Pender, M. Welch, *Education pays 2016: The benefits of higher education for individuals and society,* New York, NY:College Board, 2023.

[2] W.W. McMahon, *Higher learning, greater good: The private and social benefits of higher education*, Baltimore, MD: The John Hopkins University Press, 2009.

[3] B.A. Allan, P. Garriott, S.J. Ko, H.M. Sterling, A.S. Case, "Classism, work volition, life satisfaction, and academic satisfaction in college students: A longitudinal study," *Journal of Diversity in Higher Education*, vol. *16 no.* 1, pp. 66-75, Feb. 2023.

[4] A.W. Astin and L. Oseguera, "The declining 'equity' of American higher education," *The Review of Higher Education*, vol. 27, no. 3, pp. 321-341.

[5] J.C. Dalton and P.C. Crosby, "Widening income inequalities: Higher education's role in serving low income students," *Journal of College and Character,* vol. 16, no. 1, pp 1-8, Mar. 2015

[6] M.E. Engberg and D.J. Allen, "Uncontrolled destinies: Improving opportunity for low-income students in american higher education," *Research in Higher Education*, vol. 52, no. 8, pp. 786-807, Mar. 2011.

[7] A.J. Kezar, M. Walpole, & L.W. Perna, "Engaging low-income students," *Student engagement in higher education: Theoretical perspectives and practical approaches for diverse populations,* pp. 237-255, New York, NY: Routledge, 2015.

[8] M.B. Paulsen and E.P. St. John, "Social class and college costs: Examining the financial nexus between college choice and persistence," vol. 73 no. 2, pp.189-236, Mar.-April 2002.

[9] M. Walpole, "Socioeconomic status and college: How SES affects college experiences and outcomes," *The Review of Higher Education*, vol. 27, no.1, pp.45-73, Fall 2003

[10] G.L. Martin, B. Williams, & C. Reynolds Young, "Understanding social class as Identity," *New directions for student services*, n. 162, pp. 9-18, Spr. 2018.

[11] S.A. Atwood, S.K. Gilmartin, and S. Sheppard, " Defining first-generation and low-income students in engineering: An exploration," in *ASEE Annual Conference proceedings, June 22-26, 2020*.

[12] J.M. Smith and J.C. Lucena, " 'How do I show them I'm more than a person who can lift heavy THINGS?' the funds of knowledge of low income, first generation engineering students," *Journal of Women and Minorities in Science and Engineering*, vol. 22 no. 3, pp. 199-221, Dec. 2016.

[13] M.K. Orr, N.M. Ramirez, and M.W. Ohland, "Socioeconomic trends in engineering: Enrollment, persistence, and academic achievement", in *ASEE Annual Conference & Exposition, June 26-29, 2011*, pp. 22-1307.

[14] M.J. Hansen, M.J. Palakal, and L.J. White, "The importance of STEM sense of belonging and academic hope in enhancing persistence for low-income, underrepresented STEM students," *Journal for STEM Education Research*, pp. 1-26, May 2023.

[15] S. M. Ovink, W. C. Byrd, M. Nanney, and A. Wilson, "'Figuring out your place at a school like this:' intersectionality and sense of belonging among stem and non-STEM college students," *PLOS ONE*, vol. 19, no. 1, Jan. 2024.

[16] T.L. Strayhorn, "Sense of belonging and STEM students of color in college," *College Students' Sense of Belonging*, pp. 87-106, New York: Routledge, 2018.

[17] S. McLaren, "Sense of Belonging to the General and Lesbian Communities as Predictors of

Depression Among Lesbians," *Journal of Homosexuality*, vol. 56, no. 1, pp. 1–13, Jan. 2009, doi: https://doi.org/10.1080/00918360802551365.
[18] R. F. Baumeister and M. R. Leary, "The need to belong: Desire for interpersonal attachments as a fundamental human motivation," *Psychological Bulletin*, vol. 117, no. 3, pp. 497–529, 1995, doi: https://doi.org/10.1037/0033-2909.117.3.497.
[19]T.L. Strayhorn, "Sentido de Pertenencia," *Journal of Hispanic Higher Education*, vol. 7, no. 4, pp. 301–320, Oct. 2008, doi: https://doi.org/10.1177/1538192708320474.
[20] L.H. Anderman, T.M. Freeman, "Students' sense of belonging in school," *Advances in motivation and achievement*, 2004.
[21] C.S. Gattis et al., " Work in Progress: A path to graduation: Helping first-year low income, rural STEM students succeed," in *2019 ASEE Annual Conference & Exposition, June 16-19.*
[22] L. A. Locke and T. L. Trolian, "Microaggressions and Social Class Identity in Higher Education and Student Affairs," *New Directions for Student Services*, vol. 2018, no. 162, pp. 63–74, Jun. 2018, doi: https://doi.org/10.1002/ss.20262.
[23] J.C. Major, "Class-and Citizen-passing in Engineering: How Nando succeeded by hiding in plain sight," in *2019 IEEE Frontiers in Education Conference (FIE)* (pp. 1-9). IEEE.
[24] P. O. Garriott, S.-J. "Stella" Ko, S. B. Grant, M. Jessen, and B. A. Allan, "When Race and Class Collide: Classism and Social-Emotional Experiences of First-Generation College Students," *Journal of College Student Retention: Research, Theory & Practice*, p. 152102512199548, Feb. 2021, doi: https://doi.org/10.1177/1521025121995483.
[25]D. J. Nguyen and A. Herron, "Keeping up with the Joneses or feeling priced out?: Exploring how low-income students' financial position shapes sense of belonging.," Journal of Diversity in Higher Education, Apr. 2020, doi: https://doi.org/10.1037/dhe0000191.
[26] G. M. Bettencourt, "'I Belong Because It Wasn't Made for Me': Understanding Working-Class Students' Sense of Belonging on Campus," *The Journal of Higher Education*, vol. 92, no. 5, pp. 1–24, Jan. 2021, doi: https://doi.org/10.1080/00221546.2021.1872288.
[27] D. R. Means and K. B. Pyne, "Finding my way: Perceptions of institutional support and belonging in low-income, first-generation, first-year college students," *Journal of College Student Development*, vol. 58, no. 6, pp. 907–924, Sep. 2017, doi: https://doi.org/10.1353/csd.2017.0071.
[28] K. Rainey, M. Dancy, R. Mickelson, E. Stearns, and S. Moller, "Race and gender differences in how sense of belonging influences decisions to major in STEM," *International Journal of STEM Education*, vol. 5, no. 1, Apr. 2018, doi: https://doi.org/10.1186/s40594-018-0115-6.
[29] D. J. Nguyen, "Low-income students thriving in postsecondary educational environments.," *Journal of Diversity in Higher Education*, Dec. 2021, doi: https://doi.org/10.1037/dhe0000360.
[30]S. Havlik, N. Pulliam, K. Malott, and S. Steen, "Strengths and Struggles," *Journal of College Student Retention: Research, Theory & Practice*, vol. 22, no. 1, pp. 118–140, Sep. 2017, doi: https://doi.org/10.1177/1521025117724551.
[31] J. Major and A. Godwin, "Towards making the invisible engineer visible: a review of low-socioeconomic students' barriers experiencing college STEM education," in *2018 IEEE Frontiers in Education Conference (FIE)*, pp 1-9, October 2018

[32] H. A. Daniels, S. E. Grineski, T. W. Collins, and A. H. Frederick, "Navigating Social Relationships with Mentors and Peers: Comfort and Belonging among Men and Women in STEM Summer Research Programs," *CBE—Life Sciences Education*, vol. 18, no. 2, p. ar17, Jun. 2019, doi: https://doi.org/10.1187/cbe.18-08-0150.

[33] G. M. Walton, C. Logel, J. M. Peach, S. J. Spencer, and M. P. Zanna, "Two brief interventions to mitigate a 'chilly climate' transform women's experience, relationships, and achievement in engineering.," *Journal of Educational Psychology*, vol. 107, no. 2, pp. 468–485, 2015, doi: https://doi.org/10.1037/a0037461.

[34] L. J. Sax, J. M. Blaney, K. J. Lehman, S. L. Rodriguez, K. L. George, and C. Zavala, "Sense of Belonging in Computing: The Role of Introductory Courses for Women and Underrepresented Minority Students," *Social Sciences*, vol. 7, no. 8, p. 122, Jul. 2018, doi: https://doi.org/10.3390/socsci7080122.

[35] D. Wilson *et al.*, "Belonging and Academic Engagement Among Undergraduate STEM Students: A Multi-institutional Study," *Research in Higher Education*, vol. 56, no. 7, pp. 750–776, Mar. 2015, doi: https://doi.org/10.1007/s11162-015-9367-x.

[36]C. L. Bowen, A. W. Johnson, and K. G. Powell, "Critical Analyses of Outcomes of Marginalized Undergraduate Engineering Students," Oct. 2020, doi: https://doi.org/10.1109/fie44824.2020.9273827.

[37]I. Salusky, L. Monjaras-Gaytan, G. Ulerio, N. Forbes, G. Perron, and E. Raposa, "The Formation and Role of Social Belonging in On-Campus Integration of Diverse First-Generation College Students," *Journal of College Student Retention: Research, Theory & Practice*, p. 152102512210927, Apr. 2022, doi: https://doi.org/10.1177/15210251221092709.

[38] J. Aizenman, C. King, T. Kling, L. Ramsey, J. Solomon, S. Waratuke, C. Womack, "Interdisciplinary research and STEM-focused social science curriculum support retention and impact perception of science in cohort of S-STEM scholarship students," *Journal of STEM Education: Innovations and Research*, vol. 23 no. 1, Jan.-Mar. 2022.

[39] I. Chaterjee, K. Scalaro, A.M. Vollstedt, J.C. LaCombe, J.M. Williams, and A. Kirn, "S-STEM: Creating retention and engagement for academically talented engineers". In *2021 ASEE Virtual Annual Conference Content Access*, *July 2021*.

[40] S. Rodriguez, B. Le, and M.L. Espino, "'It's not about making money, but it kind of is about making money': How socio-economic status influences science and engineering identity for community college students in an S-STEM program," in *2020 ASEE Virtual Annual Conference Content Access, June 2020.*

[41] B.M. Wright, S. Lee, K. Zaromatidis, and O.Huk, "Increasing Retention of STEM Students with Financial Need via the NSF S-STEM DESIRE Scholarship Program," *Journal of STEM education*, vol. 22, no. 4, Dec. 2021, Accessed: Feb. 08, 2024. [Online]. Available: https://par.nsf.gov/biblio/10378591

[42] L. Zhu, J. R. Gurganus, C. Eggleton, R. Ma, T. Topoleski, and D. Madan, "Identifying NSF S-STEM Sponsored Program Activities that Have a Positive Impact on Mechanical Engineering S-STEM Scholars," *mdsoar.org*, Jun. 2020, Accessed: Feb. 08, 2024. [Online]. Available: https://mdsoar.org/items/130071bb-24aa-4117-9e78-49b228fbc2a8

[43] L. Zhu, S. Sun, L. D. Timmie Topoleski, C. Eggleton, R. Ma, and D. Madan, "Evaluation of STEM Engagement Activities on the Attitudes and Perceptions of Mechanical Engineering S-STEM Scholars," *Journal of Biomechanical Engineering*, vol. 143, no. 12, Sep. 2021, doi: https://doi.org/10.1115/1.4051715.

[44] J. L. Smith, E. Cech, A. Metz, M. Huntoon, and C. Moyer, "Giving back or giving up: Native American student experiences in science and engineering.," *Cultural Diversity and Ethnic Minority Psychology*, vol. 20, no. 3, pp. 413–429, Jul. 2014, doi: https://doi.org/10.1037/a0036945.
[45] B. S. Bassett, "Better Positioned to Teach the Rules than to Change Them: University Actors in Two Low-Income, First-Generation Student Support Programs," *The Journal of Higher Education*, vol. 91, no. 3, pp. 353–377, Aug. 2019, doi: https://doi.org/10.1080/00221546.2019.1647581.
[46] A. Kezar, S. Gehrke, and S. Elrod, "Implicit Theories of Change as a Barrier to Change on College Campuses: An Examination of STEM Reform," *The Review of Higher Education*, vol. 38, no. 4, pp. 479–506, 2015, doi: https://doi.org/10.1353/rhe.2015.0026.
[47] E. Holcombe and A. Kezar, "Ensuring Success Among First-Generation, Low-Income, and Underserved Minority Students: Developing a Unified Community of Support," *American Behavioral Scientist*, vol. 64, no. 3, p. 000276421986941, Sep. 2019, doi: https://doi.org/10.1177/0002764219869413.