WIP: Systematic Review of Sense of Belonging Interventions in Engineering and Computing Education: Bridging the Research to Practice Gap

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Work-in-Progress: A Systematic Review of Interventions to Improve Students' Sense of Belonging in Engineering and Computing Education

Abstract

Sense of belonging plays a critical role students' academic journey, serving as a predictor of students' persistence, achievement, and well-being in engineering and computing education. Despite its recognized importance, educators often lack clear and actionable guidance on feasible belonging interventions and how to implement them effectively. This work-in-progress paper addresses the gap by presenting preliminary findings from a systematic review of intervention-focused studies on sense of belonging in engineering and computing education conducted over the past decade. The identified sense of belonging interventions are organized by the level at which they operate (e.g., individual, classroom, program/institution-level) using Bronfenbrenner's socio-ecological lens. For each intervention, intervention and implementation characteristics, reported effectiveness, and outcomes are systematically extracted and synthesized. Preliminary findings indicate that practice-ready interventions are most often structured around repeated implementations (e.g., sustained peer mentoring or cohort-based structured), address structural barriers (e.g., time, cost, and access), and are supported by implementation resources for faculty or mentors.

Keywords: sense of belonging; engineering and computing education; first-year students; systematic review; interventions.

I. Introduction & Background

Despite a recent surge in research on sense of belonging in engineering and computing education, its translation into everyday teaching and program design remains limited. This research-practice gap is partly attributable to the absence of timely overviews that synthesize the growing body of knowledge for practitioners, such as instructors. In K-12 and higher education, where sense of belonging research is more established, there has been a growth in synthesis studies to address what practitioners need to know (e.g., interventions, best practices) to inform practices to enhance students' sense of belonging [41]. Yet, in engineering and computing education, where the sense of belonging field is still emerging, limited attention has been given to evidence synthesis [40], overlooking the critical role of evidence synthesis as both a catalyst for the growth of the research field and a bridge between research and practice [42].

This study consequently addresses the research-to-practice gap by synthesizing sense of belonging intervention evidence into effective guidance to practitioners, with particular emphasis on first-year contexts where sense belonging uncertainty is often greatest[4][8][9]. In higher education, students' sense of belonging is shaped by students' experiences of acceptance, connection, and legitimacy within classrooms and co-curricular environments [4][6][8]. First-year students may encounter threats to belonging due to large class sizes, competitive climates, implicit expectations, or limited access to supportive communities [4] [15][23][33].

Synthesis research has been highlighted as an effective way of addressing the research-practice gaps through translating the rapidly increasing academic publications into accessible and usable knowledge that meets the particular needs of researchers and practitioners [45]. Among different

synthesis methods, a systematic review that generate knowledge enriched by diverse interpretive lenses and are effective in evaluating the feasibility and appropriateness of practices [44], making it appropriate for the current study. The sense of belonging interventions reviewed in this study range from brief classroom-level, course-embedded activities to institution-level, multi-component programs and structural supports. Because these interventions operate at various levels of the educational system, this study adopts Bronfenbrenner's socio-ecological model [43], which explains that individuals develop through continuous interactions with surrounding systems. This approach is consistent with broader educational research indicating that multi-tier and ecological or environmental strategies can be particularly effective [3], facilitating the synthesis by enabling clearer alignment between evidence and stakeholder action.

II. Methods

This work is part of a larger multi-methods synthesis research project on sense of belonging in engineering and computing education. The larger synthesis research project was guided by the Preferred Reporting Items for Systematic reviews (PRISMA) guidelines [39], as well as a pilot scoping review conducted by the research team [40]. We identified literature from six selected academic databases (Web of Science, Engineering Village, ERIC, Academic Search Complete, APA PsychINFO, and ACM Digital Library) using Boolean search strings [39] [40] developed with aid from our engineering librarian for each database to ensure that we were able to obtain all relevant articles for the scoping review. We used Covidence, a scoping and systematic literature review management website, to aid in our abstract and full-text review. Based on our inclusion and exclusion criteria, we identified relevant literature from January 2015 to August 2024, provided it was written in English, published as a peer-reviewed journal article or conference proceeding, and focused on student populations in the context of engineering and computing education.

For the current study, we developed a separate set of research questions with inclusion and exclusion criteria to identify interventions aimed at enhancing students' sense of belonging. The abstract and full-text reviews were conducted using the corpus generated for the larger project, identifying a total of 35 articles for the current study.

Research Questions

- ***RQ1:*** What intervention types have been evaluated to improve Sense of belonging in engineering and computing education?
- ***RQ2:*** What implementation details enable adoption and subsequent adaptation, particularly in first-year contexts?
- ***RQ3:*** What outcome patterns (quantitative and qualitative) are reported, and for whom?

For data extraction, we extracted items on interventions and their characteristics (e.g., intervention components, context, target population, implementation condition, etc.), effectiveness, and outcomes. Extracted data was analyzed in two steps: (1) categorizing each intervention by the context of intervention (e.g., individual-level, classroom-level, institution-level, etc.) based on Bronfenbrenner's socio-ecological model while [43], (2) grouping them into intervention families with shared characteristics. The categorized data were then synthesized to identify shared or unique characteristics (e.g., co-occurring design features, effectiveness, outcomes, etc.) in order to generate practice-oriented knowledge useful for practitioners at varied educational levels. This approach follows structured synthesis guidance for heterogeneous evidence [1], [2] and uses

connectedness-focused synthesis to clarify construct boundaries during coding [3]. We followed PRISMA guidelines for synthesizing diverse research findings [1] [2] and applied a connectedness-focused synthesis approach, which helps us clearly define what "belonging" means in each study while we code the data [3]

III. Preliminary Findings & Discussions

A. Categorization of Intervention

This work in progress paper presents findings from a pilot analysis and categorization. To make the current study actionable for practitioners at varied levels of educational system, the study categorized the identified interventions by their context and characteristics, grounded in Bronfenbrenner's socio-ecological model [43]. According to the findings from the pilot analysis, sense of belonging interventions in engineering and computing span a wide range of formats and settings, ranging from individual-level interventions associated with students' beliefs and interpretive narratives (e.g., belonging messages with writing activities that provide a low-cost, brief reflection task designed to normalize academic struggle and encourage students to articulate personal connections to the discipline [33], narrative/video activities [23]), to classroom-level interventions relevant to peer interactions and classroom climate (e.g., ecological belonging in a first-year programming course [4], course-embedded peer mentoring [18]), and institution-level interventions and structures (e.g., bridge programs [27], career-connected micro-internships [6]). Multi-level intervention designs were also identified [9]. For each category, interventions were then grouped into intervention "families" with shared characteristics, as presented in Table 1, along with their core components and effectiveness.

Table 1. Belonging-Enhancing Intervention Families: Components, Effectiveness, and Examples.

Categories	Intervention Families	Core components	Effectiveness	Examples
Individual-level	Social-belonging message + writing	Belonging-normalization message; reflective writing for a future student	Mixed/limited effects in some first-year math contexts	First-year engineering students complete a "College Transition Assignment" where they read stories from upperclassmen about initial belonging doubts that resolved over time, then write reflective essays to future students normalizing these struggles [33].
	Values affirmation	Short values-writing exercise	Null effects on belonging/recognition in one first-year context	Marginalized gender students select personally important values (e.g., independence, achievement, benevolence) from a list and write brief essays explaining why

				these values matter to them, counteracting stereotype threat in introductory engineering courses [21].
Classroom-level	Ecological belonging (course-embedded norm setting)	Course-specific narratives; normalize struggle; facilitated discussion	Promising as a protective factor for marginalized students; may improve course task performance	In first-year programming courses, instructors facilitate a single-class session where students read course-specific narratives from previous students about overcoming coding struggles, followed by small-group discussions that normalize adversity as surmountable with effort [26].
	Peer mentoring embedded in required courses	Near-peer small groups; structured agenda; training	Promising; mentor-major alignment may matter in some programs	In introductory engineering courses, upper-level "compa" mentors facilitate weekly small-group sessions providing academic support, normalizing linguistic diversity (using Spanish), and helping mentees navigate university resources while building social capital[18].
Institution-level	Bridge programs (including online synchronous)	Academic preparation plus repeated community routines	Belonging and mattering can increase over multi-week programs	Four-week virtual summer bridge programs for incoming engineering students use near-peer mentoring, daily video check-ins, collaborative lunches with discussion themes, and elevator pitches to build community, resulting in increased sense of belonging and college mattering over the program duration [27].
	Career-connected micro-internships / project sprints	Short paid/stipended team projects; mentor support; reflection	Belonging and welcomedness often improve; outsider feelings may persist	Underrepresented computing students participate in 3-week paid "Sprinternships" where employer partners pose real technical challenges; students work in teams to

				deliver solutions, building professional networks and increasing belonging, with 78-81% reporting job offers afterward [6].
	Scholarship/community-of-practice programs	Cohort identity; advising; community events; mentoring	Identity/belonging pathways reported; designs vary	Flit-Path Community of Practice scholarship program provides computing students with three one-on-one meetings with diverse role models, three advising sessions, community events, and virtual career fairs over a semester, significantly increasing computing identity constructs including recognition, performance/competence, and sense of belonging compared to matched controls [7].

First, individual level interventions associated with students' psychological beliefs (e.g., messages, writing, or short reflections) are found to be attractive due to their cost effectiveness [37][21]. Yet, the findings show mixed results in first-year engineering and computing contexts. According to Weaver et al. [33], a social-belonging message-and-writing intervention in first-year engineering math increased sense of belonging for underrepresented students but showed limited impacts on students' performance or retention outcomes. Perkins et al. [21]'s study on a values affirmation intervention reported that the intervention did not considerably alter sense of belonging ($p=.278$) for students with marginalized genders, indicating the need for a more structured design for the writing interventions. Similarly, Reckinger et al' [29] study on a narrative-based belonging intervention in a CS course reported no statistically significant differences in sense of belonging before and after the intervention.

Second, classroom-level interventions are often embedded in a course and aim at classroom norm setting or creating peer mentoring structure [9][18]. For example, Godwin et al. [4] investigated an ecological belonging intervention in a first-year programming course that aimed to change the students' perception of their previous experiences of struggles (to belonging) through discussions, while reinforcing help-seeking as a shared norm. The findings showed that the intervention functioned as a protective factor against belonging loss and was associated with higher MATLAB performance for Black, Latinx, and Indigenous students (intervention mean grade 0.91 vs. 0.66 in control). The authors conducted a series of studies on ecological belonging interventions [9], [15], [26], emphasizing the needs for faculty buy-in, fidelity decisions, and feasibility across courses and campuses to scale the intervention.

Peer mentoring is another intervention family of classroom-level interventions, typically aiming to create repeated and structured contact with near-peers or mentors to enhance sense of belonging. For example, according to Golding and Joslyn's work [18] on a peer-mentoring intervention embedded into a first-year engineering course sequence, PromESA, the mentor-major alignment

component was critical in the effectiveness of intervention as it was associated with increased sense of belonging. A virtual mentoring model for senior engineering students, GradTrack [11], also demonstrated its effectiveness in increased sense of belonging with impacts on student outcomes (e.g., 62% of program seniors applied and were accepted to graduate school). Studies on peer mentoring interventions [5],[11],[12],[18] often emphasized sustained communities and mentoring, and targeted resources for the greater effectiveness of the intervention, rather than single implementations.

Lastly, the institution-level intervention (e.g., cohort and pathway programs) typically combines academic support with community-building to enhance sense of belonging by reducing early isolation. For example, in an online synchronous summer bridge program for incoming first year engineering students that integrated math review with structured community routines, Cohan et al. [27] observed significant increases in both belonging ($F(3,120)=9.35$, $p<.001$) and mattering ($F(3,117)=8.96$, $p<.001$) across a four-week. Another example is a CS Redshirt pre-major pathway created in response to large retention gaps [31]. The findings showed that baseline one-year retention for the pre-major group ranged from 48% to 76% (2016–2018) compared to 73%–78% for CS majors, and migration into CS was extremely low (0%–7%), underscoring the significance of pairing structured sense of belonging and academic supports in pathway program designs.

Nadelson et al. [34] investigated Makerspaces as a sense of belonging intervention in undergraduate preparation programs. The findings showed positive associations among makerspace participation and sense of belonging, motivation, and engineering knowledge, suggesting makerspaces can function as community-building learning spaces when intentionally designed and utilized. Lastly, Kramarczuk et al. [6] investigated micro-internships and career-focused programs that aim to strengthen sense of belonging and access to authentic computing work, Sprintership and Career Launch. The study reported that the majority of participants remained or became positive on items such as feeling welcomed in computing (Sprinternship 97%; Career Launch 92%). At the same time, reductions in 'feeling like an outsider' were less consistent (Sprinternship 65%; Career Launch 55%), indicating that 'welcomedness' and 'outsider feelings may change differently and require tailored climate and mentoring supports.

B. Synthesis

Looking across intervention families reveal patterns that individual studies rarely make visible on their own. By comparing results across contexts and designs, we examine where findings converge and diverge, and what conditions appear to shape impact (Table 1). The synthesis enables a more nuanced understanding of the underlying mechanisms, the contextual limits that influence effectiveness, and the key implementation considerations that are essential for both practitioners and future research.

First, embedded ecological and multi-component designs tend to align belonging support with routine coursework and thereby reduce access inequities. For instance, ecological belonging interventions in first-year courses pair norm-setting with authentic course descriptions and show promise as protective factors for marginalized students [4],[26]. Second, the evidence suggests that sense of belonging can improve by means of systematic relationships even when academic support is the explicit program goal. For example, PromESA and other course-embedded mentoring models (e.g., A, B, and C) stress predictable weekly contact, training, and navigation to resources as mechanisms for belonging [18],[11]. Third, several studies emphasize outcome divergence: Kramarczuk et al. show that 'feeling welcomed' can improve more than 'not feeling

like an outsider,' and Weaver et al. reveal higher perceived belonging for underrepresented students without parallel gains in retention [6], [33]. Finally, performance outcomes may shift even when belonging measures do not: Rhee et al. reported higher course grades in a belongingness intervention condition while post-test belonging scale differences were not detected, suggesting that some benefits may emerge through engagement, help-seeking, or performance pathways not captured by a single belonging scale [37].

A second pattern concerns access and selection. Several interventions are optional or co-curricular, which can strengthen belonging for participants, although risks leaving out students with the least time or social capital. For instance, Murzi et al. describe a voluntary research program (Icarus) that students joined to apply theory to real problems and work with peers; participants reported improved inclusion and mentoring relationships, but the model depends on students opting in [13]. Work's review of low-income engineering students similarly emphasizes that belonging interventions are sometimes unsuccessful when they add unpaid time, hidden costs, or complex navigation burdens; the most feasible designs reduce participation barriers (stipends, embedded supports, clear pathways) [8]. These contrasts reinforce why course-embedded and pathway-based interventions are often more equity-aligned than purely optional offerings.

C. Practical recommendations for first-year stakeholders

Translating evidence into action requires guidance tailored to the realities of first-year programs. Drawing from cross-study patterns and intervention summaries (Tables 1), this section provides practical recommendations for instructors, advisors, program leaders, and student-success staff, who must make decisions under constraints such as large enrollment courses, limited staffing, commuter or work schedules, and uneven access to mentoring. The guidance emphasizes feasible implementation choices, the support necessary for effective delivery (including training, materials, and fidelity checks), and a minimal evaluation approach to monitor equitable improvements in sense of belonging. The objective is to provide a practical recommendation for selecting and implementing evidence-informed interventions without requiring stakeholders to navigate the entire research literature independently.

Table 2 Practical Recommendations for Implementing Belonging Supports in First-Year Engineering Courses

Stakeholder	Action (first-year feasible)	What to watch for	Minimal evaluation
Course instructor	Deliver one early ecological belonging session tailored to the course challenges	Tone must validate struggle without minimizing; ensure discussion norms	Pre/post belonging item + short open response; course performance indicators
Course coordinator	Embed stable peer groups and structured peer-mentoring check-ins inside class time	Mentor training and matching constraints; protect time for meetings	Participation rates; belonging change by subgroup; end-of-term reflection
Program director	Run a bridge/community program (online or in-person) that prioritizes repeated interaction	Commuter/time-poor student accessibility; schedule predictability	Weekly belonging/mattering check-ins; retention into term 2

Department/institution	Reduce structural barriers (hidden costs, unpaid time) and expand paid opportunity access	Equity impacts; ensure support reaches those with highest constraints	Utilization metrics; belonging surveys; opportunity access by subgroup

For instructors and first-year program leaders, the strongest 'no-regrets' pattern is to give precedence to interventions that students will actually experience (embedded in required courses or structured pathways) and that create repeated contact. Ecological belonging sessions in gateway courses provide a compact model that can be delivered within a single class period when paired with facilitator guidance and course-specific narratives [4], [26]. Where mentoring capacity exists, course-embedded peer mentoring (e.g., PromESA) can reduce participation barriers for time poor students through incorporating support into class time [18].

At the program level, bridge and cohort models provide a useful approach to building early networks; Cohan et al. provide a measurement example by tracking weekly belonging and mattering and demonstrating statistically significant gains over a four-week online bridge [27]. For pre-major pipelines or 'at-risk' entry pathways, redshirt-style models highlight the importance of pairing community-building with academic scaffolds and transparent milestones to support migration into the major [31]. Finally, when adopting brief message-and-writing activities, practitioners should treat them as supplements and evaluate them with subgroup checks; Weaver et al.'s mixed outcomes and Perkins et al.'s null findings illustrate why structural reinforcement and careful timing are essential [33], [21].

A minimal evaluation plan can be drawn directly from the reviewed studies: measure belonging (and, when possible, mattering) at multiple points, pair those measures with at least one course or program outcome, and review subgroup patterns. For example, Cohan et al. demonstrate how weekly belonging and mattering tracking can detect significant change over a short bridge sequence, while Godwin and Perkins et al. illustrate how belonging patterns can be consistent with course performance indicators in a first-year gateway course [27], [4]. This combination helps stakeholders avoid over-interpreting a single survey snapshot and supports iterative improvement.

IV. Conclusion

This work in progress synthesis identified interventions that aimed at enhancing engineering and computing students' sense of belonging and categorized them according to study context or intervention characterization. Findings from the pilot synthesis indicate that more effective sense of belonging interventions tend to involve consistent and repeated implementation that communicates membership and support, rather than one-time or isolated activity. From a practice-first perspective, the findings suggest that interventions ought to be selected based on what stakeholders can reliably implement with fidelity given constraints related to time, staffing, training, and then evaluated using simple, context-specific measures. This pilot synthesis will inform the methods and structure of the project's synthesis, strengthening its rigor through a more detailed synthesis of intervention mechanisms and contexts.

Preliminary findings further suggest that implementable sense of belonging interventions for first-year engineering and computing students share four key features. They are embedded in required experiences, foster repeated relationships, reduce barriers to participation, and include supports for implementers. Next steps include refining synthesis and developing a practitioner-facing repository of intervention 'recipes' that summarize core components, required resources, and common implementation risks [1],[2].

References

[1] Z. Munn, M. D. J. Peters, C. Stern, C. Tufanaru, A. McArthur, and E. Aromataris, "Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach," BMC Medical Research Methodology, vol. 18, no. 143, 2018.

[2] M. D. J. Peters, C. Godfrey, P. McInerney, H. Khalil, P. Larsen, C. Marnie, D. Pollock, A. C. Tricco, and Z. Munn, "Best practice guidance and reporting items for the development of scoping review protocols," JBI Evidence Synthesis, vol. 20, no. 4, pp. 953-968, 2022.

[3] C. A. Davies, R. Cordier, P. Graham, D. Littlefair, R. Speyer, and D. Melo, "Interventions to improve connectedness, belonging, and engagement in secondary schools: A systematic review and meta-analysis," Education Sciences, vol. 15, no. 5, p. 582, 2025.

[4] A. Godwin and H. L. Perkins, "Belonging in Engineering for Black, Latinx, and Indigenous Students: Promising Results From an Educational Intervention in an Introductory Programming Course," IEEE Transactions on Education, vol. 67, no. 1, Feb. 2024.

[5] I. Aydin, M. V. Villani, and L. Cullington, "Analyzing the Impact of Multi-Faceted Women in Computing Support Programs on Women Computing Students," in Proc. ASEE Annual Conference & Exposition, 2024.

[6] K. A. Kramarczuk et al., "Micro-internships and Career Focused Programs as Mechanisms for Diversifying Computing," in Proc. ACM SIGCSE Technical Symposium on Computer Science Education, 2024.

[7] M. Kargarmoakar, "The Impact of a Community of Practice Scholarship Program on Students' Computing Identity," ACM Transactions on Computing Education, 2024.

[8] A. Work, "Increasing Sense of Belonging for Low-Income Engineering Students: A Review of Barriers, S-STEM Programs, and Future Directions," in Proc. ASEE Annual Conference & Exposition, 2024.

[9] L. DeAngelo et al., "Board 281: Fidelity and Transferability of an Ecological Intervention to Transform Engineering Representation at Scale," in Proc. ASEE Annual Conference & Exposition, 2024.

[10] A. J. Kaneria et al., "Belonging, Engagement, and Wellbeing in Informal CS Programs (Resource Pedagogy-Based)," in Proc. ACM SIGCSE Technical Symposium on Computer Science Education, 2024.

[11] L. C. Arinze, J. M. Beagle, and J. E. McDermott, "Assessing the Effectiveness of the GradTrack Virtual Mentoring Program," in Proc. ASEE Annual Conference & Exposition, 2023.

[12] I. Aydin, "Measuring the Impact of Budding Support Programs for Women Undergraduates in Computing Degrees," in Proc. ASEE Annual Conference & Exposition, 2022.

[13] H. Murzi, J. Torero, K. Sevilla, and J. Gattas, "Understanding Participation in a Voluntary Research Program to Increase Engineering Students' Engagement: An Exploratory Case Study (Icarus)," in Proc. ASEE Annual Conference & Exposition, 2018.

[14] P. Prasad, M. Balse, and J. Madathil Warriem, "Understanding Students' Experiences in an Online Programming Course from a Transactional Distance Perspective," in Proc. ACM SIGCSE Technical Symposium on Computer Science Education, 2023.

[15] L. DeAngelo et al., "The Process of Building Faculty Buy-in for Course-based Adaptations of an Ecological Belonging Intervention to Transform Engineering Representation at Scale," in Proc. ASEE Annual Conference & Exposition, 2023.

[16] S. Dory et al., "Examining Gender Inclusivity through Sense of Belonging in a Summer Research Experiences for Undergraduates (REU) Program at a Large Research University," in Proc. ASEE Annual Conference & Exposition, 2023.

[17] H. Fathima and K. Nyarko, "Holistic Review of a Multi-Site Combined REU/RET Program and the Long-Term Effects of Hybrid Instruction," in Proc. ASEE Annual Conference & Exposition, 2023.

[18] C. H. Joslyn and P. Golding, "Piloting a Socio-Culturally Responsive Peer-Mentoring Program to Promote HLX+ Students' Sense of Belonging in Engineering Education: Lessons Learned from Year 1 (PromESA)," in Proc. ASEE Annual Conference & Exposition, 2023.

[19] S. Amato-Henderson and J. Sticklen, "The Relationship between Teaming Effectiveness and Online Students' Sense of Connectedness in a First-Year Engineering Program," in Proc. ASEE Annual Conference & Exposition, 2020.

[20] A. N. Lewis et al., "Learning about the Experiences of Chicano/Latino Students in a Large Undergraduate CS Program," in Proc. ACM SIGCSE Technical Symposium on Computer Science Education, 2022.

[21] H. Perkins, E. Berger, and J. Major, "Potential of a Values Affirmation Intervention for Marginalized Gender Students' Belonging and Recognition," in Proc. ASEE Annual Conference & Exposition, 2022.

[22] R. Nagel et al., "Student Competency, Autonomy, and Relatedness in a Practice-Oriented Engineering Program: An Application of Self-Determination Theory," in Proc. ASEE Annual Conference & Exposition, 2022.

[23] S. J. Reckinger, "A Study of the Effects of Oral Proficiency Exams in Introductory Programming Courses on Underrepresented Groups," in Proc. ACM SIGCSE Technical Symposium on Computer Science Education, 2022.

[24] S. Seibel et al., "Women More Likely to Have a Sense of Belonging in Coding Bootcamps than University CS Programs," in Proc. ACM SIGCSE Technical Symposium on Computer Science Education, 2022.

[25] C. Spence et al., "Working Full Time and Earning an Engineering Degree: Wellbeing in a Co-Op-Based Engineering Program," in Proc. ASEE Annual Conference & Exposition, 2022.

[26] L. DeAngelo et al., "Course-based Adaptations of an Ecological Belonging Intervention to Transform Engineering Representation at Scale," in Proc. ASEE Annual Conference & Exposition, 2023.

[27] C. L. Cohan et al., "Sustainable Bridges from Campus to Campus: The Creation and Conduct of Online Synchronous Summer Bridge Programs in 2020," in Proc. ASEE Annual Conference & Exposition, 2021.

[28] N. O. Oquendo-Colon et al., "Women's Autonomy, Relatedness and Competence: A Comparison of Engineering Programs in Two Different Cultures," in Proc. ASEE Annual Conference & Exposition, 2021.

[29] S. M. Reckinger, C. Gregg, and B. E. Hughes, "Social-belonging Intervention in a Computer Science Systems Course," in Proc. ASEE Annual Conference & Exposition, 2021.

[30] J. Wiggins and J. R. Gurganus, "WIP: Assessing Engineering State of Mind of First-Year Undergraduate African American/Black Students in Scholar Programs," in Proc. ASEE Annual Conference & Exposition, 2021.

[31] G. C. Gannod, A. R. Crockett, J. M. Cox, and S. Y. Marshall, "Addressing Challenges of Community and Academics for CS Pre-Majors: CS Redshirt Program," in Proc. ACM RESPECT, 2016.

[32] R. G. Jabaji et al., "WIP: The Role of an Onboarding Program in Fostering a Sense of Belonging and Sociocultural Competence in New Engineering Students," in Proc. ASEE Annual Conference & Exposition, 2021.

[33] J. P. Weaver, M. S. DeCaro, and P. A. Ralston, "Limited Support for Use of a Social-Belonging Intervention with First-Year Engineering Students," Journal of STEM Education Research, vol. 4, pp. 47-72, 2021.

[34] L. S. Nadelson et al., "Student Perceptions of and Learning in Makerspaces Embedded in Their Undergraduate Engineering Preparation Programs," in Proc. ASEE Annual Conference & Exposition, 2020.

[35] E. A. Sanders, M. H. Goldstein, and G. M. Forman, "Toward an Understanding of the Effect on Summer Programming on Early Engineering Student Outcomes," in Proc. ASEE Annual Conference & Exposition, 2020.

[36] B. A. Bucher, "Graduate Student Support: Using Wellness Programming to Promote Connection, Community, and Sense of Belonging," in Proc. ASEE Annual Conference & Exposition, 2017.

[37] J. Rhee, C. Johnson, and C. M. Oyamot, "Preliminary Findings Using Growth Mindset and Belonging Interventions in a Freshman Engineering Class," in Proc. ASEE Annual Conference & Exposition, 2017.

[38] E. Judson et al., "What is the Effect of Establishing Programs that Address Sense of Belonging on Undergraduate Engineering Retention?" in Proc. ASEE Annual Conference & Exposition, 2021.

[39] A. C. Tricco, E. Lillie, W. Zarin, et al., "PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation," *Ann. Intern. Med.*, vol. 169, no. 7, pp. 467-473, Oct. 2018, doi: 10.7326/M18-0850.

[40] C. U. Lawrence and E. Lee, "WIP: Sense of belonging research in engineering education: Preliminary results from a scoping literature review," *Proceedings of the IEEE Frontiers in Education Conference (FIE)*, Oct. 2024, doi: 10.1109/FIE61694.2024.10892980.

[41] S. G. A. van Herpen, M. Meeuwisse, W. H. A. Hofman, and S. E. Severiens, "A head start in higher education: The effect of a transition intervention on interaction, sense of belonging, and academic performance," *Studies in Higher Education*, vol. 45, no. 4, pp. 862–877, 2020, doi: 10.1080/03075079.2019.1572088.

[42] D. Gough *et al*., "Evidence Synthesis International (ESI): Position Statement," *Systematic Reviews*, vol. 9, no. 155, 2020, doi: 10.1186/s13643-020-01415-5.

[43] U. Bronfenbrenner, *The Ecology of Human Development: Experiments by Nature and Design*. Cambridge, MA, USA: Harvard University Press, 1979.

[44] Z. Munn, M. Peters, C. Stern, C. Tufanaru, A. McArthur, and E. Aromataris, "Systematic Review or Scoping review? Guidance for Authors When Choosing between a Systematic or Scoping Review Approach," BMC Medical Research Methodology, vol. 18, no. 1, Nov. 2018, doi: https://doi.org/10.1186/s12874-018-0611-x.

[45] M. Borrego and C. Henderson, "Increasing the Use of Evidence-Based Teaching in STEM Higher Education: A Comparison of Eight Change Strategies: Increasing Evidence-Based Teaching in STEM Education," J. Eng. Educ., vol. 103, no. 2, pp. 220–252, Apr. 2014, doi: 10.1002/jee.20040.