A Review of Literature Examining Leadership and Mentoring Influence Upon Engineering Student Perceptions of Belonging, Motivation, Persistence and Achievement

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Abstract

Quantitative and qualitative studies of leadership and mentoring published between 1983–2025 were reviewed, with focus given to studies examining their influences within curricular, co-curricular and pre-professional engineering contexts. Multiple studies identified influences upon students' motivation, persistence, achievement, and their sense of belonging to their college and the engineering profession. In particular, leadership and mentoring exposure within project-based activities was shown to promote technical and professional engineering skill development and enhance students' engagement, self-efficacy and belonging. Several demographic factors (race, ethnicity, sex, socioeconomics) were found to impact mentoring and leadership influences, due to differences in activity preferences and participation frequency. Comparative assessment of these studies identified several relative research gaps, including (1) contrasts of mentoring and leadership influences in curricular, co-curricular and pre-professional contexts, (2) contrasts of such influences for undergraduate and graduate students, (3) socioeconomic-based impacts upon access to leadership and mentoring relationships, and (4) a need for longitudinal study data on leadership and mentoring benefits. Notably, multiple co-curricular and pre-professional activities were found to promote student engagement across experience levels but exhibited limited participation by socioeconomically disadvantaged students. Further study is warranted to better understand how this can impact disadvantaged students' achievement, motivation, persistence and belonging.

Introduction

Within engineering curricula, project-based design courses are employed to mature students' critical thinking, problem-solving skills, and ability to function within teams [1] - [3]. Such courses inspire collaboration and innovation [3], increase self-efficacy [4], and promote students' sense of belonging to the engineering profession by enhancing their motivation and persistence

[5]. Some co-curricular and pre-professional activities, including engineering competition teams (ECTs), laboratory research and internships, provide additional opportunities for students to enhance their academic engagement and develop professional competencies [5] [6].

Furthermore, such co-curricular and pre-professional activities present opportunities for students to experience leadership and mentoring within non-peer engineering networks [5] [7] - [10], which often provide sustained psychological and emotional support [11] [12], positive role models, and positive career development outcomes [13]. Comparatively, project-based coursework is less likely to provide such support mechanisms, since student relationships are typically peer-level, and demands for institutional knowledge transfer (sociological pattern maintenance) are much lower than in ECTs, laboratories and internships [14].

Some students will not have access to or engage in ECTs, laboratory research and internships due to institutional and academic factors [15][16]. Underrepresented and socioeconomically disadvantaged students are less likely to participate in certain activities, such as ECTs and research labs [16] [17]. A sense of belonging, sustained support and positive role models have been found particularly important to students from historically underrepresented demographics exhibiting elevated rates of socioeconomic disadvantage in several studies [18] - [23]. There is a continued need to understand how such students encounter leadership and mentoring experiences that support belonging across demographics.

This paper summarizes a review of three lines of literature: (1) experiential learning and the development of student engineering and professional competencies, as well as student self-efficacy, engagement and sense of belonging, (2) the influence of leadership and mentoring upon students' sense of belonging and achievement, and (3) demographic differences in participation, leadership/mentoring exposure, and belonging, with a focus on socioeconomic influences. This review is important because leadership and mentoring are core features of several co-curricular and pre-professional activities that foster students' connection to their college and profession [5]. These activities provide opportunities for engagement across experience levels with an emphasis on institutional knowledge transfer; these elements are often not present in curricular activities like project-based capstone courses [11] [14]. As a result, socioeconomically disadvantaged students may have fewer opportunities to access leadership and mentoring, thereby affecting their sense of belonging, motivation, persistence and achievement [6] [16].

Focus was given to reviewing studies of experiential learning, leadership, mentoring and demographic influences conducted within engineering college and university settings, as their findings are most directly transferrable to engineering education. However, several foundational studies of leadership and mentoring were conducted in industry settings and have been included herein to help introduce the theoretical foundations of leadership and mentoring study. Similarly, engineering practices have benefited from research conducted in the fields of science and medicine, so related studies from those fields have been included as they enhance discussion of leadership and mentoring benefits and demographic influences.

Experiential Learning Influence on Competencies, Belonging and Engagement

European reform universities (such as McMaster, Maastricht and Aalborg) began introducing problem-based and project-based curricular instruction in the 1960s and 1970s [24]. In the 1990s and 2000s, American colleges of engineering began incorporating such approaches within their curricula (initially within undergraduate "capstone" courses and later within first year "cornerstone" courses) to provide realistic design environments that encourage exploration and teamwork [1]. Employing the constructivist variant of the cognitivist learning framework [25], such courses increase student engagement, encourage higher-level thinking, and apply engineering theories to the solution of practical design problems.

Over the past twenty years, academic studies have shown that the project-based approach develops both technical and professional engineering skills. For example, undergraduate electrical engineering students' achievement and perceptions of learning were studied by Yadav et al. (2011) using an A-B-A-B instructional design ("A" representing traditional lectures and "B" representing problem-based instruction) [26]. Fifty-five students were assessed using pre-post testing and completed a Student Assessment of Learning Gains (SALG) survey including both Likert-scale ratings and open-response questions. Although students believed they learned more from traditional lectures due to familiarity, their performance on assessments was nearly twice as strong on topics taught using problem-based instruction. Jiusto and DiBiasio (2006) explored self-directed learning (SDL) skill development within the Worcester Polytechnic Institute's experiential Global Studies Program [27]. Three research instruments were utilized: the SDL Readiness Scale (a 58-item Likert-scale questionnaire examining learning attitudes), the Individual Development and Educational Assessment (IDEA) student ratings of instruction system (self-reported progress on learning objectives), and faculty reviews of team reports. A modest improvement in student readiness for SDL was identified, and students reported greater confidence in problem solving.

Project-based capstone courses often incorporate complex design considerations and requirements, which benefit students by promoting interdisciplinary collaboration. Student self-efficacy in a cross-disciplinary team learning (CDTL) environment was studied by Schaffer et al. (2012) by surveying 303 participants in an undergraduate service-learning program (n = 112) at a Midwestern university [4]. Elements within the survey addressed technical knowledge and skills, team contributions and interdisciplinary integration. Exploratory factor analysis found that self-efficacy and confidence were influenced significantly by both task complexity and team composition. Hotaling et al. (2012) compared academic and professional outcomes within monodisciplinary (137 students) and multidisciplinary (31 students) engineering courses [28]. Logistic regression analysis was used to explore relationships between design team scores, students' GPA and job placement rates; additionally, independent industry reviewers assessed the quality of team products. In whole, products developed by multidisciplinary teams were judged superior in utility and innovation, with students in multidisciplinary courses exhibiting higher employment rates seven months after graduation.

Competitions within project-based courses permit students to experience the full design cycle, the benefits of which have been reported in several case studies. For example, a vehicle design competition in a Master's level design course at Cardiff University was described by Davies (2013) [29]. A post-course survey indicated that students' desire to make their vehicles more competitive increased their engagement and attentiveness in class. Similarly, surveys conducted by Gadola and Chindamo [2] and Hanh [3] after incorporating multi-university design competitions within design courses indicated that the competitions motivated students to improve their products by devoting more time to discussion and brainstorming than they would have within traditional design courses.

Project-based undertakings promote student engagement, defined as the time and effort students devote to academics, co-curricular activities (complementing the curriculum) and extracurricular activities (unconnected to academics). Simmons et al. (2018) used student engagement as a metric to identify those activities perceived as being the most beneficial, surveying engineering students at three public R1 universities (n = 845) as classified by the Carnegie Classification of Institutions of Higher Learning [16]. Odds ratios were used to compare activity participation rates based upon student demographic characteristics. High participation rates were identified for ECTs and professional experiences, implying that students prioritize such engineering-oriented activities as being academically and professionally beneficial. Patterns of belonging and community connections were investigated by Wilson et al. (2014) at four disparate universities (a public R1 research university, a private faith-based university, a historically Black college, and a teaching-focused university) [6]. Voluntary response surveys were obtained from over 1,000 engineering and computer science sophomores, juniors and seniors over the course of three years. Students who were active in co-curricular activities reported greater academic emotional engagement and self-efficacy than did less-active students.

Engineering students' sense of belonging to their university, their college/department and the profession can also be enhanced through project-based activities. The contributions of curricular, co-curricular and extracurricular activities to belonging, motivation and persistence at a public R1 research university were explored by Lee et al. (2025) [5]. A survey examining how belonging is influenced by university and engineering college programs, project-based learning (PBL) courses, internships, research, and student organizations obtained over 5,000 voluntary responses. Using exploratory factor analysis and structural equation modeling, the investigators found that internships and PBL coursework were strongly correlated with academic achievement, motivation, persistence and belonging. Powers et al. (2018) explored how undergraduate research and internship participation influence career choices and aspirations [30]. Their investigation included a quantitative analysis using the National Science Foundation's Engineering Majors Survey 1.0 database of responses from 6,187 junior and seniors, as well as semi-structured interviews with 20 students completing a summer internship at a large engineering company. The researchers found that research and internship exposure positively impacted their self-efficacy as well as short and long-term career expectations.

While co-curricular research activities contribute to student learning, Carter et al. (2016) found that curricular activities have the greatest impact upon engineering skills competence [15]. The benefits of undergraduate research activities and their impact upon leadership, teamwork and communication skills were studied using a stratified sample of data from the American Society for Engineering Education's institutional and program-level database for the 2007-08 academic year. Response data from 5,136 students at 31 engineering colleges were evaluated using exploratory factor analysis, that identified four curricular scales of interest (core engineering thinking, professional skills, broad and systems perspectives, and professional values). The investigation concluded that while students who participate in undergraduate research self-report higher professional skill levels, the benefit of undergraduate research experiences upon teamwork and leadership skills is not statistically significant when curricular and classroom experiences are accounted for.

In combination, this line of literature indicates that project-based learning, within coursework as well as co-curricular activities, develops both technical engineering skills (critical thinking and problem solving) and professional skills (teamwork, communication) that enhance student achievement. It also suggests that project-based activities motivate students to innovate and collaborate, increase academic engagement, enhance self-efficacy and persistence, and promote students' sense of belonging. These influences are illustrated in Table 1, which shows the division of papers by context, type of study and attributes studied. However, it does not assess how leadership and mentoring exposure within such activities contributes to student self-efficacy, engagement, persistence and belonging. While several studies surveyed relatively large numbers of students (e.g. exceeding 1,000 respondents), these were primarily cross-sectional in nature and did not assess project-based activity benefits over time. Also, most studies focused upon undergraduate engineering student populations and did not compare their experiences to those of graduate students.

Leadership and Mentoring Roles in Achievement, Motivation and Belonging

College students benefit from leadership and mentoring exposure in curricular, co-curricular, pre-professional and extracurricular activities, that promote motivation and belonging and help develop professional skills. Impacts of leadership and mentoring exposure have been studied in both university and professional settings.

Leadership Roles

Leadership identity development (LID) theory, that is based upon a relational model which considers inclusivity, purpose, process, empowerment and ethics, has been used to examine how personal self-conceptions as leaders are affected by different experiences [31]. As a directional developmental theory (sequential progression through leadership identify stages), LID integrates psychosocial, cognitive, developmental synthesis and social identity families of developmental theories [32]. LID in engineering competition teams was studied by Wolfinbarger et al. (2021), using structured interviews to classify the LID stages and behaviors of fourteen ECT participants [33]. The researchers concluded that LID was accelerated by project complexity, team immersion, exposure to coaching, and providing coaching. Similar conclusions were developed by Shuman et al. (2005) who found that low complexity team activities may not sufficiently challenge the team, nor may they provide an environment that encourages intense team member interaction [34].

Before the 1990s the focus of college leadership development was within co-curricular and extracurricular activities, but over the past three decades the development of leadership and other professional skills has become a core component of many curricular business and engineering programs [35]. Leadership education has grown into an area of curricular study and research that advances knowledge and develops professional leaders, approaching "leadership as a process and not just a position" [35]. Co-curricular, extracurricular and internship pursuits now function as complementary activities contributing to leadership identity and skill development, providing support systems and promoting belonging to the profession.

Academic studies have investigated the influence of different university experiences upon leadership development. Knight and Novoselich (2017) studied how undergraduate engineering students' experiences affect self-reported leadership, conducting disproportionate random sampling of 5,076 students within 6 disciplines at 23 universities [36]. A hierarchical linear model was developed relating demographic characteristics, engineering discipline, instructional characteristics, curricular emphasis and co-curricular engagement to leadership skill development. The model results implied that curricular activities produced stronger relationships with leadership skill development than co-curricular activities, prompting the researchers to recommend coursework addressing the development of leadership and professional skills. Cox et al. (2010) investigated approaches for incorporating leadership education within engineering curricula [37]. Twelve engineering faculty members at a Midwestern university were interviewed, answering questions about leadership elements within capstone design courses, extracurricular activities, and practical experiences. Exposing students to multiple leadership roles in different segments of capstone courses was judged to be an effective approach to obtaining leadership experience, especially for students who would not innately seek out a leadership role.

Ahn et al. (2014) sought to identify undergraduate engineering student outcomes that relate to leadership, adaptability to change, and synthesis [38]. Using a mixed methods approach, they first interviewed 23 engineers (12 in academia and 11 in industry) to determine leadership, change and synthesis constructs using a constant comparative method analysis. Subsequently, they developed an instrument to assess these constructs (consisting of 59 items, of which 37 addressed leadership, 13 explored change and 9 focused on synthesis) and administered it to 753 students at a large Midwestern university. A Q-sort approach and complementary exploratory factor analysis were used to identify four underlying factors behind the large number of items: 1) being an engineering leader, 2) impact on society and economy, 3) engineering leadership and 4) development of an adaptor to change. The authors concluded that leadership includes individual and team aspects, that change and synthesis are interrelated, and that synthesis requires both engineering and nontechnical topics to create well-rounded engineers.

Mentoring Roles

Often described in the context of teaching and coaching, mentorship extends beyond these functions by developing collaborative and personal relationships which help mentees clarify their life and career goals, provide psychological and emotional support, and introduce positive role models [18]. Effective mentors demonstrate strong interpersonal skills such as listening, feedback techniques, and positive reinforcement methods.

Mentoring is “relational and developmental,” having career (instrumental) and psychosocial (relational) functions, “includes phases and transitions”, and depends upon trust, empathy and respect [39]. Mentors help protégés acquire a deeper conceptual understanding, improve problem-solving abilities, and develop confidence to work independently [40]. In a seminal paper, Kram (1983) examined 18 relationships between younger and older managers at a large northeastern public utility, conducting interviews to understand the phases of mentoring relationships [41]. Four consistent and predictable phases were identified: initiation (a relationship is started), cultivation (the mentoring functions provided expand to a maximum), separation (the relationship is altered by psychosocial changes or adjustment of the organizational context), and redefinition (the relationship evolves to a different form). She determined that mentoring relationships include career functions (coaching, sponsoring, increasing visibility) as well as psychosocial functions (using emotional support to enhance identity and self-efficacy). When examining the evolution of effective student-faculty mentoring relationships, McKinsey (2016) characterized these stages as “Mentoring In” (orientation and “learning the ropes”), “Mentoring Through” (increasing confidence and independence), “Mentoring Onward” (career preparation and sponsoring) and “Continuing Relationship” (collegiality and friendship) [42].

Since Kram’s studies were published in the 1980s, several researchers have examined various mentoring contexts in the college environment. Nabi et al. (2025) performed a systematic review of papers published between 1986 and 2023 addressing mentoring and its impact upon student career development [13]. Most studies reported a positive relationship between mentoring exposure and career development outcomes, with career mentoring functions relating positively to career planning and psychosocial mentoring functions relating positively to professional identity, self-efficacy and career optimism. Crisp (2009) investigated the construct validity of the College Student Mentoring Scale (CSMS) using four latent variables: Psychological and Emotional Support, Degree and Career Support, Academic Subject Knowledge Support, and Existence of a Role Model [43]. Stratified random sampling from courses at a south-central US community college obtained 351 responses. Results suggested that undergraduate college student mentoring may be defined as "Support provided to college students that entails emotional and psychological guidance and support, help succeeding in academic coursework, assistance examining and selecting degree and career options, and the presence of a role model by which the student can learn from and copy their behaviors relative to college going." Vielma et al. (2025) conducted a case study of mentoring experiences under a National Science Foundation Research Experiences for Undergraduates program [44]. Mentors who were consistently rated as effective exhibited availability, were transparent about career experiences, and discussed working in academia in a realistic and balanced way.

Engineering mentorship practices have taken advantage of extensive mentoring networks within the medical and veterinary sciences, for which much scholarly research has been published. Watson et al. (2025) surveyed 133 scholarly articles published between 2015 and 2025 that were associated with nursing and education, identifying 16 papers addressing the role of mentoring in doctoral nursing student training [45]. Core themes included the importance of mentor competence and expertise, mutual respect, availability, approachability, communications skills, and valuing diverse perspectives. Strong mentors fostered professional identity and commitment to the profession. Koziol and Wagner (2024) examined student perspectives during the first year of a new faculty-student mentoring program at Texas Tech's School of Veterinary Medicine [46], surveying 148 students at the beginning and end of the academic year (n = 136 at beginning, n = 56 at end). Respondents reported that the mentorship program helped them build relationships with faculty and other students, receive guidance, and develop a sense of belonging to the program. The validity of a mentoring program questionnaire for health professions bachelor's level courses was investigated by Rogan et al. (2018) using a cross-sectional study [47]. Physiotherapy students (n = 129) at the Bern University of Applied Sciences responded to a survey containing 24 items. Construct validity was verified through a confirmatory factor analysis. The final version of the mentoring questionnaire identified a four-factor solution (use, behavior, formal specifications and role) consisting of ten survey items.

Beyond traditional mentoring of individual students, university faculty may mentor entire teams of students in curricular activities. Xie et al. (2021) used semi-structured interviews and direct observation to study team mentoring during a design competition held three times per semester at a large university in the United States [8]. Team mentoring was examined using a temporal theoretical structure, and nine mentoring actions were identified: initiation, developing thinking, design processes, keeping the team on-track, empathizing with the team, monitoring team dynamics, offering support, supplying information, and providing career advice. The authors grouped these nine actions into teamwork process actions and teamwork foundation actions.

Engineering students can experience mentoring beyond the curricular environment. Since ECT, research laboratory and internship experiences expose students to colleagues with varying experience levels, their constructs seem conducive to the formation of mentoring relationships. In a quantitative study, Goller et al. (2020) examined workplace characteristics impacting the engagement of engineering interns [12]. Questionnaire responses obtained from a convenience sample of 121 engineering students completing long-term internships were analyzed using structural equation modeling. The analysis indicated that challenging tasks motivated interns to seek guidance, subsequently prompting the formation of beneficial mentoring relationships. Damkaci et al. (2017) discussed the implementation of a chemistry lab peer mentor program and resulting student outcomes [7]. Students in peer-mentored laboratories were found more likely to remain as chemistry majors and demonstrated higher university retention and graduation rates. Additionally, peer mentoring appeared to strengthen student relationships which extended beyond the laboratory.

Even undergraduate students can find opportunities to mentor others. Taylor et al. (2023) studied undergraduate mentor experiences at a youth engineering camp [19]. A qualitative study of written reflections and interviews indicated that the camp volunteers used prior experiences and funds of knowledge to develop their approach to mentoring and were motivated to help the younger students. The implementation of a progressive mentoring model within an offshore geohazards project conducted at five universities was studied by Santora et al. (2013) using a voluntary response survey [11]. Analysis of the survey results implied that students at all levels can be mentors if they possess appropriate knowledge, skills and confidence. Student-mentor relationships were sustained after the program, increasing students' sense of belonging. Packard et al. (2014) examined peer mentoring practices within a science laboratory at a women's liberal arts college in Massachusetts, interviewing six faculty, five peer mentors and five newer students using semi-structured questions [48]. Laboratory experience was found to be a significant factor in establishing credibility and being sought out as a peer mentor, rather than upper-level student status. Through coaching and support, faculty equipped peer mentors to be knowledgeable resources to the newer students.

In whole, this line of literature suggests that leadership and mentoring experiences are crucial to engineering students because they advance career development and achievement, engineering identity and belonging. Internship, research laboratory and ECT experiences can help accelerate leadership skills development and provide mentoring opportunities to obtain career, psychological and emotional support. However, studies indicate that students perceive that coursework is more important in developing leadership and professional skills. While curricular, co-curricular, pre-professional and extracurricular experiences have been studied for their leadership and mentoring benefits, these different experiences have not been directly contrasted to better understand the distinct benefits they provide to student achievement, motivation, persistence and belonging. Also, while numerous studies incorporated quantitative surveys, these were primarily cross-sectional in nature and focused upon limited student cohorts (e.g. a single university, competition team or research laboratory), with much lower participation (e.g. below 1,000 respondents) than the studies described in the first line of literature (experiential learning influences). The division of leadership and mentoring-focused papers based upon context, type of study and attributes studied is presented in Tables 2 and 3.

Influence of Demographic Factors on Persistence, Motivation and Belonging

Multiple investigators have studied student demographic characteristics (sex, gender identity, race, ethnicity, and socioeconomic status) within co-curricular and extracurricular activities to better understand how participation, skill development, motivation, emotional engagement and belonging are influenced by these factors. As stated by Marra and Pangborn [18], it is crucial for historically underrepresented students to "see themselves in the profession" by interacting with peers and mentors who "look like them". Mentors who share an identity with a student cohort are more likely to be capable of supporting their career development based upon shared values and student identification with the mentor [13]. Correspondingly, mentors are motivated to serve as role models and increase these students' participation in engineering careers [19].

The majority of such studies have focused upon demographic factors like race, ethnicity, sex and gender identity, with lesser scholarly activity and emphasis given to socioeconomic considerations and related factors (e.g. first-generation status, full time vs. part time enrollment). For example, race/ethnicity and gender influences upon student engagement within activities were investigated by Simmons et al. (2018) [16]. A purposeful survey collected data from universities graduating large numbers of students from historically underrepresented cohorts, who were found to have higher odds of high engagement in engineering outreach support organizations and lower odds of participating in ECTs. Based upon this, the researchers concluded that universities should promote participation of underrepresented students on such teams to increase their participation rates and engagement. Wilson et al. (2014) included race/ethnicity, gender, and parents' educational level as variables while developing regression models connecting academic emotional engagement and co-curricular participation [6]. Female and racially/ethnically underrepresented students were purposefully oversampled. The researchers found that involvement in co-curricular activities can strengthen the relationship between self-efficacy and academic emotional engagement and identified a marginally significant negative relationship between emotional engagement and participation in women and minority-focused organizations.

Underrepresented and disadvantaged students value leadership and mentoring exposure. The impact of undergraduate students' research participation upon their professional skill development was investigated by Carter et al. (2016), who included gender, race, ethnicity and other demographic factors as covariate indicators [15]. Service as a leader in an engineering professional society or club correlated positively with professional skill development, especially within clubs focused on female and/or minority student aspirations. Part-time students who struggled to devote extensive time to co-curricular activities demonstrated less leadership and teamwork skill development. Crosson et al. (2025) examined a UN Sustainable Development goals summer research program, in which faculty mentors actively targeted underrepresented first through third year science and engineering students [10]. Using a convergent parallel mixed method design, both qualitative data (site observations, one-on-one interviews) and quantitative data (student and mentor surveys) were obtained. Most participants reported retention of cohort and mentor relationships after the program, with ¾ reporting greater confidence in pursuing a STEM career.

Patterns of student-faculty interaction at a large research university system were studied by Kim and Sax (2009) to understand whether the frequency of interactions varied due to student race, ethnicity, gender, social class and first-generation status [49]. Survey responses were gathered from 58,281 students at nine University of California campuses. Statistically significant differences were identified in student-faculty interactions related to research; males were more likely to assist as volunteers or for pay, while females more frequently assisted for credit, and economically underprivileged students were more likely to assist for pay. Less-privileged students were determined to have fewer faculty interactions than privileged students. Scherer (2020) examined variations in mentoring experiences based upon social class and college context using a qualitative study [50], interviewing 68 students in total at both a public flagship research university and at a regional teaching-focused university in the same state. Privileged students engaged more easily with faculty, asked more questions and made more requests than did less-privileged students who generally deferred to faculty and maintained a low profile. Less-privileged students at the regional university had a higher frequency of positive interactions with faculty due to the faculty's focus on teaching over research, reporting greater belonging to the university as a result.

Similar benefits from mentoring have been found in studies of upper-level scholars and faculty. Mendez et al. (2023) investigated the mentoring needs of Latinx and Black engineers seeking tenure-track faculty positions, interviewing 13 postdoctoral scholars [21]. Mentoring priorities included network expansion, application support, and coaching to promote work-life balance (relieving stress and burnout), whereas secondary needs included technical skill enhancement as well as guidance on understanding and managing biases in academia. Mentoring relationships with underrepresented early career faculty were studied by Zambrana et al. [14]. Qualitative data from focus groups and one-on-one interviews were obtained from 58 faculty members at 22 research-focused universities. Over 90% of respondents reported having a relationship with a mentor. Key characteristics of ideal mentorship included mutual respect, appreciation of scholarship, awareness of historical marginalization and barriers, and providing access to academic opportunities and networks.

Altogether, this line of literature suggests that student race, ethnicity, sex, gender and sociologic factors affect co-curricular and extracurricular participation rates as well as the choices students make regarding activities to participate in. Underrepresented and disadvantaged students and scholars are drawn to activities which enhance their skills and achievement, professional networking and sense of belonging, and mentors want them to feel included. However, the majority of studies did not explicitly examine relationships between socioeconomic factors and participation rates, access to leadership and mentoring relationships, and their contributions to achievement, motivation, persistence and belonging. Rather, such factors were examined in association with race/ethnicity and sex/gender impacts. It is concerning that ECTs exhibit lower rates of participation by historically underrepresented and disadvantaged students, and that underprivileged students have fewer and less impactful interactions with faculty at flagship research universities. Multiple quantitative studies surveyed substantial numbers of students (e.g. exceeding 1,000 respondents), but primarily developed cross-sectional data for specific cohorts, potentially limiting transferability of findings. Table 4 illustrates the division of demographic-focused papers based upon context, type of study and attributes studied.

Discussion

Linking these three lines of literature, several studies [4] [5] [15] [26] found that project-based curricular, co-curricular, extracurricular and pre-professional activities can contribute to technical and professional skill development, academic engagement, self-efficacy and students' sense of belonging to their university and the engineering profession. Some activities, including internships, laboratory research and ECTs, incorporate leadership and mentoring to enhance team member skills, promote team cohesion and student perceptions of belonging, and improve student achievement. Because members of such teams typically exhibit a breadth of experience levels and value institutional knowledge transfer to perpetuate the organization, it can be inferred that these organizations strongly benefit from mentoring and leadership activities. Conversely, many curricular groups do not share such attributes. Despite these differences, the nature and attributes of leadership and mentoring exposure within curricular and co-curricular organizations have not been contrasted, nor have the mechanisms by which such exposure influences achievement and perceptions of belonging been studied in a comparative fashion.

Leadership and mentoring support and enhance project-based curricular, co-curricular, pre-professional and extracurricular experiences to promote academic engagement, motivation, persistence and belonging. Based upon these three lines of literature, it can be inferred that these end goals are based upon complementary enhancement of four intermediate attributes: 1) academic and professional competency, 2) academic emotional engagement, 3) self-efficacy and 4) engineering identity. A concept map, shown in Figure 1, was derived based upon the literature review findings to illustrate these complementary interrelationships.

Also, several academic studies [6] [15] [16] [49] [50] identified differences in co-curricular and pre-professional participation rates and perceived benefits based upon student demographics. However, the majority of studies concentrated on sex/gender and race/ethnicity factors, with lesser focus given to the influence of socioeconomic factors. Additionally, the means by which leadership and mentoring contribute to the achievement, motivation, persistence and belonging of economically disadvantaged students have not been an explicit study focus. As such, a need exists to determine whether socioeconomically underprivileged engineering students receive less leadership and mentoring exposure in their curricular, co-curricular, extracurricular and pre-professional activities than the general student population does, and if so whether this is detrimental to their academic achievement, persistence, motivation and belonging.

Within each of these three lines of literature, multiple studies address aspects of student achievement, motivation, persistence and belonging. However, there are relative gaps in assessing the benefits of experiential learning and engineering leadership exposure upon students' sense of belonging to the profession, along with a relative lack of longitudinal survey data. As illustrated in Figure 1, project-based experiences and leadership are interrelated to both belonging and achievement through the four aforementioned intermediate attributes. It is suggested that future academic studies focused upon achievement and belonging benefits from leadership and mentoring exposure be conducted to address these research gaps.

Conclusions

A substantial number of scholarly articles focused on leadership and mentoring exposure within experiential engineering activities (coursework, pre-professional, co-curricular and extracurricular) and their influences upon achievement, persistence, motivation and belonging have been published over the past twenty-five years. Such exposure helps develop technical and professional knowledge and skills, and enhances engagement, self-efficacy and engineering identity. However, such influences are affected by demographic factors, including race and ethnicity, sex and gender, as well as socioeconomic status.

This literature review identified multiple relative gaps in the historical research. While mentoring and leadership influences have been studied within curricular, co-curricular, extracurricular and pre-professional contexts, such influences have not been directly contrasted to better understand the distinct benefits they provide to students. Although qualitative and quantitative research has studied both undergraduate and graduate student experiences, the nature of leadership and mentoring influences upon graduate and undergraduate students have not been directly contrasted. While several studies concentrated on sex/gender and race/ethnicity-based factors upon leadership and mentoring exposure, lesser focus has been given to economic influences and the means by which such exposure benefits socioeconomically disadvantaged students. Many cross-sectional studies examining leadership and mentoring benefits have been conducted, whereas relatively fewer longitudinal studies have been undertaken.

It is hoped that awareness of such gaps will inspire future scholarly research which can be used to promote effective leadership and mentoring exposure and benefits to engineering students, especially those who historically receive less exposure resulting from demographic and economic influences.

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Table 1

Studies on Experiential Learning Influences on Competencies, Belonging and Engagement

Context	Type of Study	Attribute Studied			
		Achievement	Motivation	Persistence	Belonging
Curricular	Quantitative Survey	[5, 15]	[3, 5]	[3, 5]	[4, 5, 15, 27]
	Single Subject Design	[26]			
	Achievement Data Analysis	[28]			
	Case Study		[2, 29]	[2, 29]	
Co- and Extra-Curricular	Quantitative Survey	[5, 15]	[5, 16]	[5]	[5, 6, 15]
Research and Pre-Professional	Quantitative Survey		[30]	[30]	[30]
	Semi-Structured Interviews		[30]	[30]	[30]

Table 2

Studies on Leadership Influences in Achievement, Motivation, Persistence and Belonging

Context	Type of Study	Attribute Studied			
		Achievement	Motivation	Persistence	Belonging
Curricular	Quantitative Survey	[36, 38]			
	Interviews	[37, 38]			
Co- and Extra-Curricular	Quantitative Survey	[36]			
	Interviews				[33]
	Literature Review		[34]	[34]	

Table 3

Studies on Mentoring Influences in Achievement, Motivation, Persistence and Belonging

Context	Type of Study	Attribute Studied			
		Achievement	Motivation	Persistence	Belonging
Mentoring Experiences	Quantitative Survey	[7, 42, 43]	[11, 12]	[7]	[12, 42, 43, 46]
	Interviews	[8, 41]	[13]		[41, 48]
	Case Study				[44]
	Literature Review	[13]		[45]	[45]

Table 4

Studies on Demographic Influences in Persistence, Motivation, Achievement and Belonging

Context	Type of Study	Attribute Studied			
		Achievement	Motivation	Persistence	Belonging
Curricular	Quantitative Survey	[15]			[5]
Co- and Extra-Curricular	Quantitative Survey	[6, 15]	[16]		[6, 15, 16]
Research and Pre-Professional	Quantitative Survey			[10]	[10]
	Interviews			[10]	[10]
Faculty Interactions	Quantitative Survey	[49]			[49]
	Structured Interviews	[50]			[50]
Mentoring Experiences	Interviews, Focus Groups				[14, 21]

Figure 1

Concept Map Illustrating Leadership and Mentoring Interrelationships with Student Experiences Which Support Achievement, Motivation, Persistence and Belonging