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The Staying Power of Socializing Engineers: A Systematized Review

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The Staying Power of Socializing Engineers: A Systematized Review

Introduction

Many engineering graduates pursue an engineering profession, and remain involved for their entire career; however, there are also multiple career paths many choose to take that include an exit from engineering practice [1]. This phenomenon of deciding to stay or leave the engineering profession leads to a broader question: what drives some engineers to make the decision to stay in the profession, while others opt to leave? Researchers have explored factors that contribute to work satisfaction and career retention, and found self-efficacy, personal goals, and outcome expectations contribute [2], however, a comprehensive investigation is warranted to find possible commonalities and themes.

Once a graduating engineer finds employment, they are introduced to the norms of the specific organization they join [3]. During this process of socialization into the organization, new institutional supports or barriers start to influence the engineer's self-efficacy, outcome expectations, and personal goals [2]. While many studies have examined engineering retention, most focus on specific population groups within their singular study; for instance, factors affecting women, or Hispanic, or Black engineers, who leave the profession at a higher rate than the overall industry [4]. There have been a variety of both quantitative and qualitative studies, including methodologies such as case studies, grounded theory, correlational analyses, quasi-experimental studies, and more, some of which are identified in Appendix A, offering both numerical comparisons and rich investigation.

In my aim to create a resource that consolidates ample and diverse sources, and identifies and categorizes factors influencing retention and attrition among engineers, I concluded that a systematic synthesizing of the literature is deserved. I found Social Cognitive Career Theory (SCCT) [5], [6] to provide a theoretical aspect helpful to understand, explore and consolidate these factors. The findings may help enhance the direction of future research efforts, and may inform engineering organizations with insights into engineers' decision-making processes.

Specifically, this paper aims to explore the existing literature to examine how engineering socialization efforts influence engineers' decisions to leave or stay in engineering careers, using SCCT to identify key factors affecting career decisions. The research questions in this paper ask, (1) What SCCT-related factors influence career retention among engineers, particularly through mechanisms of engineering socialization?, and (2) What socialization factors have been found to increase retention, and what factors are found to increase attrition?

Theoretical Framework

Organizations aim to retain employees due to myriad reasons, including costs of recruiting, training, and lost knowledge [7]. As engineers gain experience, the specialized problem-solving and design-related practical knowledge they gained is difficult to replace [8], [9]. The retention of engineers, therefore, becomes critical not only for maintaining technical expertise, but also for minimizing the knowledge loss that occurs when engineers leave the profession. Most commonly

this issue has been depicted using the “leaky pipeline” metaphor, which highlights a progressive loss of engineers at various stages in their career journeys.

Engineers may leave the profession because of systemic barriers undermining their engagement and satisfaction, while others may stay due to perceptions of workplace supports. The origin of Social Cognitive Career Theory is centered around Social Cognitive Theory (SCT) [10]. SCT suggests that individuals, their behaviors, and their environments interact in a dynamic, reciprocative manner, and is frequently employed to explore how individuals learn from their experiences. It asserts that learning is fundamentally rooted in the belief that a behavior can be performed, and the behavior will result in a valuable and likely consequence. When extended to career decision-making and incorporating elements driving work satisfaction, Lent and Brown [6] defined SCCT with an emphasis on how self-efficacy, outcome expectations, and personal goals play pivotal roles in guiding an individual’s career trajectory.

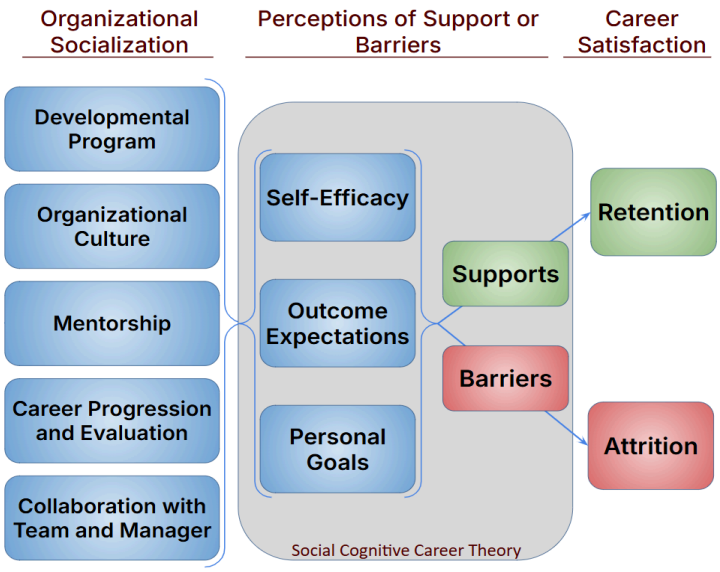
This framework closely parallels efforts to define and understand "engineering identity," a concept many researchers explore. However, SCCT also emphasizes the role of contextual and experiential factors, such as institutional support or barriers, in shaping these core variables. By integrating these factors, this theory is a particularly valuable comprehensive lens for identifying factors of professional socialization mechanisms that affect engineers’ job satisfaction and career persistence in engineering. My review will integrate the three components of self-efficacy, outcome expectations, and personal goals to identify how the socialization mechanisms act as supports or barriers as they affect career decisions.

Self-efficacy, in SCCT, is identified as an individual’s belief in their ability to perform tasks in their domain. Lent et al. [11] highlight that individuals with higher self-efficacy are more likely to pursue and persist in STEM fields, as they anticipate positive outcomes from their efforts. This view is repeated in Wingerter [12], where newcomers report that proactive engagement in socialization processes enhances their adjustment and reinforces their self-efficacy. Collectively, these studies suggest that cultivating a strong sense of self-efficacy and aligning personal goals with anticipated outcomes are essential for enhancing retention in engineering careers.

Outcome expectations refer to an individual’s belief about anticipated consequences of performing certain actions, influencing career-related decisions. Korte et al. [13] further emphasize that the work experiences of engineers are significantly shaped by their expectations regarding career advancement and job satisfaction. In fact, the same author had previously found that unsatisfactory socialization can lead to stress, disillusionment, stalled careers, lowered productivity and turnover [14]. Lutz [15] illustrates that new graduates often experience a disconnect between their aspirations and the tasks assigned to them, leading to frustration when their contributions do not align with their perceived capabilities. Studies have separately investigated how aspects of organizational career progression programs support and hinder engineers in their career development.

Personal goals are the aspirations and intentions that individuals set to guide their efforts in pursuit of desired career outcomes. Lutz et al. [16] reveal that engineers in smaller organizations often experience greater agency and support, while those in larger firms face bureaucratic constraints that hinder meaningful contributions. The alignment of personal values with

Figure 1
Conceptual Framework of the Study



organizational missions emerges as a critical factor; engineers who perceive this alignment report higher job satisfaction, whereas misalignment can lead to frustration and disengagement. For others, personal goals were set aside when others perceived they had skills congruent with management, and were encouraged to go into managerial roles even when these roles were not the best fit with their personal interests [17].

These SCCT key components are deeply interconnected and can influence one another over time. High self-efficacy in solving engineering problems leads to more positive outcome expectations, such as believing that staying in the profession will yield personal and professional satisfaction. Reinforced expectations then shape engineers' personal goals, fostering greater persistence. However, when self-efficacy is undermined, either through lack of success or negative feedback, outcome expectations may shift, leading to changes in personal goals. Thus, workplace experiences are significant: when engineers encounter barriers, such as mismatched values, it disrupts their self-efficacy and outcome expectations or, conversely, a supportive work environment fostering growth and aligning with aspirations can reinforce persistence.

The literature has identified many factors affecting career retention and engineering job satisfaction. The following systematized literature review aims to consolidate this research by examining how socialization mechanisms interact with SCCT's core components. This approach allows for a more integrated understanding of the factors that influence engineering career retention and attrition, providing insights into how workplace structures can better support engineers throughout their career trajectories as illustrated in Figure 1.

Research Methods

I conducted a systematized review to identify and synthesize factors influencing engineering career retention, specifically focusing on perceived barriers and supports within the context of

organizational socialization. This approach ensured a comprehensive and unbiased combination of relevant studies addressing this complicated issue. Following Preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines, the review examined studies that explore factors such as organization culture, developmental programs, mentoring, career progression access, and collaboration with managers and teams. I then analyzed how these perceived barriers and supports align within the theoretical framework given by SCCT, which highlights the roles of self-efficacy, outcome expectations, and personal goals. The search and selection strategy ensured that only relevant studies were included, providing a reliable foundation for understanding the mechanisms that influence engineers' career trajectories.

Databases were selected to provide literature results on both the psychological and engineering aspects of engineering education and engineering career decision-making. The specific databases initially searched were APA PyscInfo and Compendex, with no date limitations. Results were limited to journal articles, by removing and excluding all book chapters, dissertations, popular magazines and conference papers. The search was conducted on September 22, 2024, utilizing the following search terms within the abstract field: “engineer* AND career” AND “retention OR persist*” NOT “student*” NOT “teacher*” NOT “undergraduate”. Results were exported to a reference managing database (Zotero), and duplicated search results were removed. Upon review, one resulting paper, Stemming the tide: New perspectives on careers and turnover [18] was an integrative special issue of eight empirical articles, which I then treated as an additional database in my study. The APA PyscInfo database search yielded 104 results, Compendex provided 55 results, and the Kiazad et al. 2024 special issue added 8 results. Figure 2 presents the PRISMA 2020 flow chart of this review, which was managed through the Covidence software.

The criteria for inclusion were defined as: (1) population: engineers or STEM professionals currently or formerly employed in a private company in the field of their degree; (2) study design: factors related to supports or barriers and effects on self-efficacy, outcome expectations, or personal goals; (3) outcomes: career retention or attrition from the engineering field as part of the study.

In the first stage of article screening, results were removed during a title and abstract review to remove duplicate articles (N=4), conference papers, dissertations, or popular magazine results (N=53), and irrelevant articles, e.g. an article on the persistence of PFAs and a novel approach to breaking down the molecules (N=7). Full texts were then obtained for all potentially relevant articles. On further screening, 83 additional articles were removed for having an academic study population (N=32), a youth population (N=14), a population not on engineering graduates with current or past employment (N=20), or an outcome not including factors of retention in engineering or STEM fields (N=18). More detail on these exclusion criteria is presented in Table 1. After these exclusions, a total of 19 relevant articles are included in the synthesis.

Data Analysis

This qualitative synthesis was performed in two distinct steps. First, an inductive content analysis identified emerging themes on common organizational socialization mechanisms from the included articles. Second, a deductive thematic analysis considered how the participants perceived these mechanisms as supports or barriers based on SCCT constructs.

Figure 2

PRISMA 2020 flow diagram

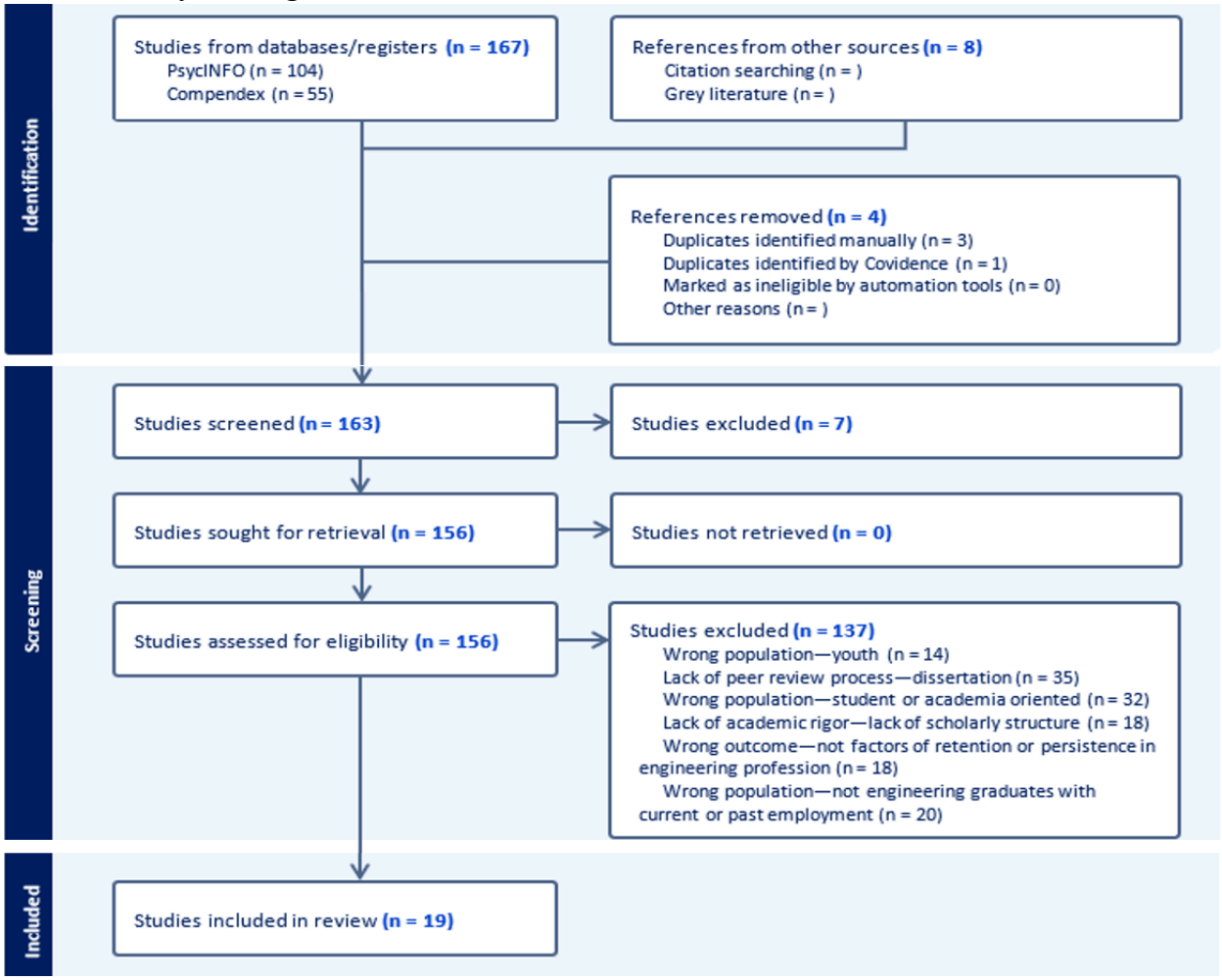


Table 1

Exclusion criteria and definitions utilized in PRISMA 2020 screening process

"Wrong population—youth"	n=14	Studies investigating youth, including high school, middle school, or grade school children.
"Wrong population—student or academia oriented"	n=32	Studies investigating university undergraduate students, graduate students, or faculty
"Wrong population—not engineering graduates with employment"	n=20	Studies investigating non-engineering careers, or engineering graduates without employment experience.
"Wrong outcome—not factors of retention in engineering profession"	n=18	Studies not investigating retention, attrition, or closely related variables like career satisfaction.
"Lack of academic rigor—lack of scholarly structure"	n=18	Popular magazine articles, articles with no citations, or not reporting any methods.
"Lack of peer review—dissertation"	n=35	Doctoral or Masters dissertations and theses.

Although my study focuses on a systematized review of research articles, these articles include qualitative, quantitative, and mixed-methods approaches, and utilize diverse methods and data sources, such as interviews, focus groups, survey responses, questionnaires, documents and media content. Content analysis is a systematic method for identifying patterns, themes and meanings within diverse data types, offering a suitable approach for synthesizing findings across these studies to find emerging types of socialization mechanisms found within organizations.

I first employed inductive thematic coding, to allow themes to emerge from the data without predefined categories. I conducted open coding as an initial step to break the data into discrete themes, which were grouped into broader categories through an iterative process. To find these themes, I created a document such that when reading the methods and findings from the included studies, I could summarize the participant interactions and find similarities. As I progressed, these groupings naturally fell into categories of participant interactions, and resulted in the identification of five categories of socialization mechanisms: developmental programs, organizational culture, mentorship, career progression and evaluation, and collaboration with teammates and managers. As with many qualitative studies, there are overlaps in these categories; for example, career progression interactions may have been with their manager or a part of the organization culture. For better repeatability, I have provided definitions in Table 2 for how I categorized these mechanisms. All categories were reported in multiple included studies and will be triangulated to ensure reliability and consistency across sources.

Within the five socialization categories identified, I applied a deductive thematic analysis guided by the constructs given by SCCT—self-efficacy, outcome expectations, and personal goals. This framework categorizes findings by examining the interactions of personal, behavioral, and contextual factors and their influence on perceptions of work satisfaction. Using directed coding, I systematically applied the SCCT constructs to the data, allowing for a structured analysis of how individuals' experiences and beliefs shape career persistence and decision-making processes. This approach helps reveal broader factors impacting career trajectories and offers a lens through which to interpret engineering career retention.

Table 2
Theme definitions utilized during content analysis coding

Developmental Programs	Programs that were organized and well-defined, with specific outcome expectations. Examples include professional development or training, HR initiatives, onboarding, or personal or professional planning programs.
Mentorship	An explicit pairing by the organization of a mentor and mentee.
Career Progression and Evaluation	Incorporated participant exposure to experience building, promotion, career progression frameworks, recognition and rewards.
Organizational Culture	Overall perceptions of organization values, expectations or judgements towards ideas such as social value, work-life balance, or pervasive tolerance of discrimination or harassment.
Collaboration with Coworkers and Managers	Localized and specific interactions of participants with other members of the organization, including social interactions, networking opportunities, or team dynamics.

While I have developed biases and preconceptions related to engineering career paths and reasons for retention or attrition over many years, for the purposes of this study, I have attempted to set aside these biases to focus objectively on the included study participants' experiences as interpreted through the SCCT framework. I have included related materials from multiple studies that relate to the same variables or experiences in an attempt to triangulate and validate findings when possible. I also compare a content analysis of the findings with the themes of SCCT in my interpretation to ensure the themes identified are consistent with the relevant constructs.

Findings

An inductive content analysis of 19 articles revealed five key themes influencing engineering career retention: developmental programs, mentorship, career progression and evaluation, organizational culture, and collaboration. These themes emerged through recurring patterns of supports and barriers discussed in the literature. Organizational culture was the most frequently mentioned, appearing in 14 articles, followed closely by career progression and evaluation in 13 articles. Collaboration was discussed in 9 articles, while mentorship and development programs were mentioned in 4 and 8 articles, respectively. Each theme reflects an aspect of the engineering workplace that either facilitates or impedes engineers' desire to persist in their careers. The list of included studies in Appendix A marks the themes found in the respective work.

The variety of themes underscores a complex nature of career retention, and each element plays a role in shaping engineers' experiences and long-term commitment. Developmental programs provide the foundation for skill acquisition, while mentorship offers essential guidance and support. Expected career progression and evaluation directly impact engineers' perceptions of future success. The organizational culture creates the environment in which engineers operate daily, for good or for bad. Collaboration, both with peers and managers, further influences engineers' sense of belonging and professional growth.

To explore the broader implications of these findings, each theme is examined through the lens of Social Cognitive Career Theory (SCCT), focusing on how contextual supports and barriers impact engineers' self-efficacy, personal goals, and outcome expectations. By applying SCCT, we aim to better understand how workplace factors contribute to the retention or departure of engineers, providing insights into effective interventions to support long-term career persistence.

Theme 1: Developmental Programs

Developmental programs were perceived as critical for equipping the necessary skills for each phase of a career, and building confidence and competence, especially during key transitions.

Upon hiring, quality training and onboarding programs facilitated smoother transitions into professional roles and increased technical and organizational competency for new engineers, resulting in higher confidence and role satisfaction [13], [19]. Similarly, on-the-job training helped refine technical skills, build confidence, and were valued by experienced engineers as helping them become more well-rounded [19]. The burgeoning self-efficacy of newly hired engineers then leads naturally to future career progression. Personal and career development planning programs were instrumental in aligning individual and organization expectations, with

engineers who articulated a personal vision and formalized development plans better understanding their future roles and career trajectories [20].

Similar to the value experienced engineers accredited to on-the-job training, further development programs, such as soft skills development, continued to help engineers build self-efficacy and to promote goal orientation and outcome expectations [21]. The most supportive organizations provided universal initiatives to help all engineers' in their professional growth [19], [22]. On the other hand, diversity-focused programs also provided opportunities, but often came with unintentional challenges. For instance, initiatives aimed at advancing women or minorities into management roles improved access to mentors and sponsors, enhanced women's organizational visibility, and for many they provided an enhanced role fit [17]. However, sometimes the programs and mentors guided women into roles that did not align with their personal goals [17]. As one participant reflected: *"I recently had a one-year stint in the managerial path… I hated it, switched back to a technical path, and disappointed most of my champions"* [17, p. 605]. These experiences underscore the need for diversity initiatives to focus on self-efficacy and role alignment rather than reinforcing stereotypes, ensuring that engineers feel empowered rather than isolated. As one participant reported, *"I don't want to be in the women's leadership group, I want to be in <u>the</u> leadership group"* [23, p. 7].

Theme 2: Mentorship

Mentorship emerged as a mechanism that provided both guidance and advocacy, serving as a critical support for navigating barriers—a significant obstacle, especially for early-career engineers and underrepresented groups.

Guidance from a mentor not only boosts early employee contributions but also enhances self-efficacy and goal setting by clarifying workplace norms and expectations [13]. An absence of mentorship led to perceptions of the opposite: *"I feel if somebody just had given me a little bit more mentoring time during an initial phase...I would have been much more productive"* [13, p. 103]. Similar to the absence of a mentor, an inadequately resourced mentorship, where either the mentor or mentee could not take the time to make the relationship work, provided no value and also led to guidance-deficient barriers [23]. For the greatest benefit, a structured and valued mentorship program tailored to the individual and their individual realities was significantly more valuable than a "find a mentor" strategy [24].

Advocacy, where mentors serve as champions who expand access to opportunities and act as a buffer, broaden mentees' exposure and access to high-profile projects. Related studies overwhelmingly related to women participants' experiences, and found that both men and women could be effective advocacy mentors [23]; however, two additional findings support a tailored approach. First, organizations that overemphasized the value of only female-to-female mentorships ultimately overburdened their senior women to a point of burnout, thus restricting the mentorship pool and undermining the program [23]. Second, some women felt dismissed by those male mentors who viewed the industry as entirely equitable, thus undermining the value of mentorship [19]. Whether a structured mentorship program was available or not, findings still support that young female engineers valued visible examples and access to successful female role-models, as the notable precedent cemented positive outcome expectations [23].

Theme 3: Career Progression and Evaluation

The progression, evaluation and recognition of engineers' careers play a critical role in career retention, affirming goals and outcome expectations.

Continuous learning opportunities, the excitement of working on novel technologies, projects, and products, and involvement in developing large, complex projects played roles in affirming self-efficacy and sometimes goal progress in a career [19], [20], [25]. One participant expressed, "I just love to see the things that we create... it's really nice to drive past or walk past a previous job." [19, p. 7]. This intrinsic affirmation shaped outcome expectations, and engineers appreciated equitable formal and informal recognition, such as bonuses, praise, or growing responsibility, to reinforce their sense of impact and professional value [25], [19].

As careers continued, a transparent, accessible and equitable structured career progression reduced uncertainty and enhanced retention [23], [26]. On the other hand, organizations that provided limited information about the promotional process, unclear feedback mechanisms, or a perception of limited opportunities for growth triggered engineers to consider leaving [13]. For some organizations, poorly enacted diversity-focused promotion policies created a stigma and atmosphere where recognition by promotion led to questioning the validity of achievements and a loss of credibility instead [26]. Additionally, gendered assumptions placed many women in managerial rather than technical advancement pathways against their personal goals and outcome expectations, masking reduced engineering identity as career progression [27], [28].

Flexible career frameworks—such as non-linear career paths, part-time roles, and re-entry programs—played a significant role in retention. Many engineers follow a non-traditional career path, taking a break from engineering jobs [1]. Non-linear career progression and flexible frameworks enabled engineers to maintain their career trajectory without feeling pressured to sacrifice advancement due to work-life conflicts or balancing their personal and professional lives [23], [29]. Conversely, many faced inflexible environments, with one participant stating, "I'm on contract... I can't take maternity leave... I won't have a job to come back to" [19, p. 8].

Theme 4: Organizational Culture

The organizational culture permeates the experience of an engineer throughout their career development and progression, and may compound or offset the extent other socialization methods affect retention.

Values of an organization that align with the individual's values led to an improved perception of progress towards goals and finding purpose in one's work, especially in roles that involved public service or community-based projects [19]. Engineers that felt a lack of impact towards the greater good reported dissatisfaction: "I tangentially helped with projects on environmental remediation, but my work felt very paltry" [30, p. 945].

Additionally, engineers valued a healthy work-life balance; however, some organizations normalized a "workaholic" culture of long work hours, where individuals felt judged when not conforming [23]. Unofficial, but inequitable, flexibility created conditions where personal goals

may conflict with the norms, for instance: “If the men want to finish their meeting and go to the pub at 2 o’clock in the afternoon it’s okay. If I want to go and pick my child up at 3 o’clock it’s not okay” [22, p. 8]. Even official flexible arrangements were at times implicitly unacceptable: “we have adopted very flexible policies where we can but we don’t broadcast it. Because if you broadcast it ... people will abuse it” [26, p. 563]. Flexible work options and career paths were particularly important for employees with or considering children, to enable those engineers to choose to stay, or be allowed to stay, in the profession [20], [23], [31].

The workplace atmosphere impacted day-to-day work life, where daily meaningful and challenging work, recognition from colleagues, and where failure is recognized as a part of learning, all contributed to feelings of accomplishment and worth [20], [32]. Engineers who felt their unique skills were valued and that they made an impact on the work environment were more likely to remain in the profession. Employees valued relaxed environments with camaraderie, where colleagues interacted socially outside of work, such as having lunch or playing volleyball after hours [13]. In contrast, a tense and stressful atmosphere led to isolation and poor support; as described by one participant, “All these people yelling at each other. They’re like-oh, that’s just how the group meetings are” [13, p. 101]. Women additionally struggled to navigate environments where rigid gender stereotypes were normalized [33]. In such environments, supportive colleague relationships became crucial, as those who felt ostracized or unsupported reported difficulties in coping with negative expectations and exclusion, and often considered leaving or shifting careers entirely [13], [33].

Discrimination and harassment was found to affect many engineers that could not be accounted for by human capital, job characteristics, work effort, family responsibilities, or other measured factors [34]. One woman reported a situation where her supervisor shared, “You did the best, but we can’t give it to you; these guys will be mortified if you get this prize” [35, p. 146]. In addition to overt harassment and exclusion, more subtle manifestations were becoming more prevalent. For instance, male colleagues who viewed technical roles as more prestigious exhibit disdain towards women in management, and continue to reinforce gendered stereotypes [17]. There is evidence that women in senior engineering roles feel isolated, with one-third of women in management positions reporting feelings of marginalization [29]. Even women who felt supported by their organization and colleagues had thoughts of leaving due to the broader organizational climate and gender-based bias [24]. Factors such as such as sexual harassment, bias in performance evaluations, and negative attention due to appearance combined to create an environment where many engineers feel that they are not able to succeed on equal terms [29].

Theme 5: Collaboration with Coworkers and Managers

Engineers interact with colleagues in several forms—as coworkers, in teams, and in a manager–subordinate relationship—each of which offer opportunities for network building, increasing self-efficacy, and achieving career goals.

Collaboration among coworkers brings a sense of belonging, especially for new graduates and early-career engineers. New hires often sought support from their peers to gauge their performance and fit within the organization [13], and it was the process of working alongside “peers, mentors, and/or experts in their field” where early-career professionals experienced the

most growth [32]. Engineers expressed frustration when they faced conflict with their colleagues, or unexpected challenges when a lack of urgency or lack of engagement by coworkers hindered productivity [13], [19]. Additionally, exclusionary practices, such as not being invited to social gatherings, reduced the ability to integrate into the team culture, limiting opportunities for meaningful collaboration, and led to disengagement [19], [34].

Group dynamics within team collaborations work to advance visibility in the organization [17], and to increase opinion sharing: "I think it has forced me to … act more forcefully with my ideas and opinions" [33, p. 1041]. However, women specifically were often assigned coordination and organizing tasks, in turn limiting their access to more technical advancement opportunities and their ability to shape their own career trajectories [17]. At the same time, women engineers often had to navigate societal expectations about how they should behave to be seen as competent, creating pressure to continuously prove oneself in professional exchanges [33].

Managerial support increased employee engagement and reduced turnover, while a lack thereof, especially when navigating conflicts, building networks or gaining resources for career advancement, led to frustration and disengagement [20], [19]. Some engineers must additionally carefully navigate inappropriate behavior by their managers, including harassment such as sexual innuendos [35], leading to significantly lower work satisfaction. On the other hand, managers that facilitated networking opportunities, such as socialization outside of work with access to senior leaders, created a platform for face-to-face interactions that facilitated professional growth, particularly valued by young engineers [23]. The study participants stressed that these events must be well-organized and equitable; it was critical that the timing, structure, and location provided an equal opportunity for all engineers to build their professional relationships, and gain valuable insights into career advancement and organizational pathways.

Discussion

These findings revealed how a variety of engineering organization socialization mechanisms affect self-efficacy, outcome expectations and personal goals for engineers. The following is meant to describe in more detail how a lens of Social Cognitive Career Theory (SCCT) may tie together the organizational support and barriers, revealing how perceptions combine and affect career retention. I aim to connect this to the broader retention literature, providing a more cohesive understanding of contributions to career choices.

Socialization Mechanisms as Support for Self-Efficacy, Personal Goals, and Outcome Expectations

Socialization experiences that provide support to engineers' self-efficacy, personal goals, and outcome expectations enhance career retention. As established by Lent et al. [36], encouragement and positive reinforcement from peers, mentors, and managers strengthen self-efficacy, which then drives persistence and career progression. Supportive socialization processes that contribute to these factors were seen across several themes in the literature. For example, mentoring programs and developmental programs foster self-efficacy, as they provide engineers with guidance and feedback, and help build confidence in their abilities and in their future career prospects. The articles in this study provide further support to the findings of

Brunhaver et al. [2], which highlighted that engineers who felt supported through mentoring or coaching were more likely to persist in their careers due to enhanced job satisfaction and increased self-confidence.

Further evidence from Korte et al. [13] and Simpson and Maltese [32] suggests that collaborative work environments, particularly among early-career engineers, provide essential support for both self-efficacy and personal goal development. As new engineers work closely with experienced peers and mentors, they gain the skills, knowledge, and confidence to take on more complicated tasks and envision a successful career trajectory. This collaborative support can bolster their personal goals, helping them align their professional aspirations with the expectations and opportunities available within the organization. For example, the sense of belonging fostered by collaboration, as discussed in Zhang et al. [19], contributes to engineers' sense of identity and engagement with their work, making them more likely to stay in the field.

Additionally, workplace structures that promote meaningful work and career advancement contribute to positive outcome expectations, reinforcing engineers' belief that their efforts will lead to desirable results. Inclusive networking opportunities where engineers interact with senior leadership were shown to provide clear pathways for career advancement, further enhancing engineers' expectations about their ability to succeed and progress [23]. Those who could balance family and career without judgment were more likely to stay in their roles, suggesting that work flexibility and family-supportive policies are essential to retaining the most diverse workforce. These experiences support engineers' belief in their potential for long-term success, especially when accompanied by recognition and support from the organization.

Socialization Mechanisms as Barriers to Self-Efficacy, Personal Goals, and Outcome Expectations

While supportive socialization mechanisms enhance self-efficacy and career persistence, barriers to these factors can have the opposite effect, leading to disengagement. Negative socialization experiences, such as interpersonal conflict, exclusion, and lack of managerial support, create significant barriers that undermine engineers' self-efficacy and the pursuit of personal goals. Coworker dynamics, particularly issues like lack of cooperation, interpersonal conflict, and exclusionary practices, can directly diminish engineers' sense of belonging and confidence in their abilities [13], [19]. These barriers to positive socialization experiences erode self-efficacy, as engineers who experience conflict or exclusion are less likely to feel that they can succeed or advance in their careers. For instance, engineers who felt excluded from social or professional activities, particularly women and minorities, often experienced decreased morale and engagement, leading to lower job satisfaction and an increased likelihood of leaving the field.

In particular, the lack of support from managers and supervisors can impede engineers' development of personal goals and outcome expectations. Inadequately resourced mentorship could result in dissatisfaction as mentors failed to guide or advocate for their mentees, leading to missed goals and poor outcomes. Women engineers, in particular, reported that inadequate managerial support, structurally and interpersonally, was a significant barrier to their career retention [20]. Similarly, women in managerial roles, despite their initial success in these positions, faced barriers such as gender stereotyping and work-life balance tensions that led to

increased attrition risk [17], [27]. Women engineers often felt the pressure to conform to societal expectations of leadership or to forgo technical roles in favor of managerial paths, which in turn decreased their sense of professional identity and commitment to engineering careers.

Additionally, a lack of professional role models, particularly female engineers in technical roles, was identified as a critical barrier for new engineers. When engineers, particularly women, were unable to see themselves in the roles they aspired to due to a lack of representation or mentorship, their outcome expectations became less optimistic [17], [29]. The absence of technical role models reinforced a sense of isolation and disconnection from the engineering community, further diminishing self-efficacy and undermining career goals.

Effects on Retention and Attrition

Consider two fictional companies:

Take Company A, where high-quality socialization methods are a bedrock of the organization. Engineers are started off on day one: you encourage a collegial relationship between coworkers and managers, insist on inclusion in appropriate and meaningful social events, assign a defined mentorship and corporate leaders expect the relationship to be prioritized for mentor and mentee. As the employee gains experience, invites to networking events that include senior leaders are common, formalized career planning, inclusive leadership, technical and professional development training are offered consistently, and the social impact of their work is celebrated. With more expertise, managers increase the employee responsibilities and provide clear promotion criteria. Non-traditional career paths are common, including meaningful part-time work, lateral moves, and an ability to rejoin after having a break from the organization. The leaders have found that by encouraging employee self-efficacy, providing expected outcomes to good work, and helping employees plan and meet their own goals, they helped the organization meet its goals as well, and had very high retention rates for their most valued engineers.

Now take Company B, where socialization methods have normalized over the organizational history. New engineers are hired, but often without a project assigned and work on menial tasks as the “new kid” for a few months. Managers and coworkers are all working long hours, and are unable or unwilling to help with questions due to time constraints and competition within the organization. Resourceful engineers make strides on the projects they get assigned, and are doing great work. They would like to socialize with their colleagues more, but Friday evenings are already busy. Many realize they are getting passed over for promotions for two reasons, 1) less experienced engineers who befriended senior managers on Fridays are getting early offers, and 2) nearly all of the women engineers are placed in the Women in Leadership program to meet the organization quota. Occasionally an engineer asks if there are part-time or flexible opportunities for a few months, and the manager dutifully offers the federally required leave, or suggests that they could quit. The leadership has noticed high attrition from engineers across the board, and that women are most likely to leave, but also know that this is normal in the industry.

The balance of supportive and inhibitive socialization factors directly impacts engineers' decisions to stay in or leave the field. Retention is most strongly associated with positive socialization experiences that align with engineers’ personal goals and outcome expectations,

while attrition is often the result of barriers that hinder self-efficacy and limit career advancement opportunities. Engineers who felt recognized for their contributions and engaged in meaningful work were more likely to remain in the field [25]. These engineers often reported positive experiences of professional identity reinforcement, where their work directly contributed to the organization's goals and their personal sense of accomplishment. Company A understands this, and prioritizes finding methods to engage their employees, leading to higher self-efficacy, and then provides clearly aligned outcomes for personal and professional goals.

On the other hand, attrition was often linked to negative workplace dynamics, such as a lack of support, poor work-life balance, or exclusion from social networks, which reduced engineers' job satisfaction and sense of belonging. Women in particular were found to be at greater risk for attrition when they encountered gendered career paths, such as being pushed toward managerial roles rather than technical ones, which decreased their professional satisfaction and sense of self-competence [27]. Engineers dissatisfied with their roles, or that felt their careers lacked meaning, were more likely to leave for non-engineering jobs, particularly when those positions provided better alignment with their personal values such as helping others [30]. This was especially true for individuals who felt that their contributions in engineering were undervalued or unappreciated. Company B fell into many of these traps unintentionally, and accidentally created many opportunities for outcome expectations to go unmet, goals to be unrealized, and self-efficacy to be challenged or belittled.

Ultimately, interventions aimed at improving retention must focus on fostering inclusive, supportive socialization processes that enhance self-efficacy, develop and align personal goals, and set realistic and positive outcome expectations for engineers.

Limitations of the Study

This review is subject to several limitations. First, the search was restricted to two databases, which may have excluded relevant studies from other sources and affected the comprehensiveness of the findings. Additionally, publication bias is a concern, as the focus on peer-reviewed articles tends to favor studies with significant or positive results. This bias can overlook important null or negative findings that may be relevant to the research questions and affect the balance of insights available for this analysis. Furthermore, although a narrative synthesis approach was applied systematically to reduce bias, it still relies on subjective interpretations, especially when connecting findings across a smaller number of studies.

These findings may be transferable to many organizational situations due to the variety among the 19 studies which were published over a span of 14 years. However, the smaller sample of articles could not accurately reflect the breadth of engineering field specializations, and may limit the generalizability of findings across other engineering areas. A larger review encompassing a broader range of engineering fields could yield additional or differing insights, providing a more diverse understanding of factors influencing career retention. Also significantly, the findings centered on larger engineering companies, yet many engineers are in smaller companies. While many of the factors found likely extend to these groups, additional studies that include these populations will improve the transferability of findings.

This work also focused on social-cognitive factors combined with perceptions of supports or barriers, but did not seek to provide any environmental conditions as a backdrop–such as the labor market or economic conditions.

Taken together, this study serves as an exploratory review rather than a comprehensive account of factors influencing career retention. Despite these limitations, the findings offer meaningful contributions to the literature, advancing our awareness of the factors impacting retention in engineering careers.

Conclusions and Implications

The findings from this systematized review highlight the critical role of engineering socialization mechanisms in supporting self-efficacy, personal goals, and outcome expectations. The included studies found evidence for many factors that increase retention, such as universal quality developmental programs, mentoring, clear promotion criteria, and fostering an atmosphere of collaboration, inclusion, and recognition employed engineers. In contrast, exclusion, discrimination, interpersonal conflict, and lack of managerial support decrease the likelihood of career persistence, reducing perceptions of ability, goal realization, and positive outcome likelihood. I envision that these results can help organizations consider new socialization strategies, and reconsider current mechanisms to improve engineer retention.

Further implications arise from how an engineer's identity is tied to these constructs of self-efficacy, goals, and outcome expectations. The process of 'becoming' an engineer often begins in high school, but can begin even earlier in a professional's life [37], [38], [39]. University experiences, including both the explicit and hidden curriculum, institutional programs and structures, and how students become engineers is well-researched, exploring factors such as identity formation, relationship with mathematics, and cultural contexts [40], [41], [42]. Findings have shown that students' abilities to translate technical competencies through universities' enculturation efforts are positive, but efforts at developing less technical skills, such as engineering communication, have been found to be more difficult to achieve in conventional programs of study [43]. Higher education institutions allocate significant resources toward developing support structures for engineering students, shaping students' beliefs in outcome expectations and the setting of personal career goals [44], [45]. Engineering education providers may benefit from orienting their efforts toward development strategies that coordinate with well-designed and supportive organizational mechanisms. I recommend further research seeking to connect whether enculturation programs at the university level affect longer term career retention.

By aligning socialization practices with the SCCT framework, organizations and educational institutions can better support engineers in navigating the challenges of the profession and help ensure their long-term career success.

Appendix A:
Studies Included in Qualitative Synthesis

Study	Method and sample	Socialization mechanism(s)
		OC | DP | M | CP | CL
Bielefeldt & Canney, 2019 [30]	Mixed-method, 465, ENGR	■ □ □ □ □
Buse & Bilimoria, 2014 [20]	Mixed-method, 495, ENGR, Women	■ ■ □ ■ ■
K. Buse et al., 2013 [35]	Qualitative, 31, ENGR, Women	■ □ □ ■ ■
Cardador, 2017 [17]	Qualitative, 61, ENGR	■ ■ □ □ ■
Cardador & Hill, 2018 [27]	Quantitative, 274, ENGR	□ □ □ ■ □
Cech, 2022 [34]	Quantitative, 25324, STEM	■ □ □ ■ ■
Cruz & Nagy, 2024 [24]	Quantitative, 515, STEM, Women	■ □ ■ □ □
Dlouhy & Froidevaux, 2024 [1]	Quantitative, 1512, STEM	□ □ □ ■ □
Fouad et al., 2016 [31]	Quantitative, 514, ENGR, Women	■ ■ □ ■ □
Khilji & Pumroy, 2019 [33]	Qualitative, 10, ENGR, Women	■ ■ □ ■ ■
R. Korte et al., 2019 [13]	Qualitative, 30, ENGR	■ □ ■ ■ ■
Maurer et al., 2021 [61]	Quantitative, 1602, ENGR	□ □ □ ■ □
Melin & Correll, 2022 [21]	Quantitative, 35, STEM, Women	□ ■ □ □ □
Servon & Visser, 2011 [29]	Mixed-method, 2493, ENGR	■ □ □ ■ □
Sharp et al., 2012 [26]	Qualitative, 77, ENGR	■ ■ □ ■ □
Simpson & Maltese, 2017 [32]	Qualitative, 99, STEM	■ □ □ □ ■
Smith et al., 2023 [23]	Qualitative, 25, ENGR	■ ■ ■ ■ ■
van der Marel et al., 2024 [25]	Qualitative, 33, ENGR	□ □ □ ■ □
Zhang et al., 2024 [19]	Qualitative, 19, STEM, Women	■ ■ ■ ■ ■

OC = Organization culture, DP = Developmental programs, M = Mentorship, CP = Career progression, feedback, and evaluations, CL = Collaboration

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