

Career-Stage Pathways of Professional Identity Development in Women Engineers: Implications for Training and Leadership Development

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Received: November 20, 2025

Accepted: February 7, 2026

Online Published: February 22, 2026

doi:10.11114/jets.v14i3.8195

URL: <https://doi.org/10.11114/jets.v14i3.8195>

Abstract

This study examines how women engineers develop their professional identity across career stages and considers implications for education, training, and leadership development. Drawing on Social Cognitive Career Theory, the study explores how engineering identity, leadership identity, and organizational culture intersect within gendered workplace dynamics. Using a grounded theory approach, we conducted in-depth interviews with 21 women engineers at different career stages and constructed stage-specific models of professional identity development based on reciprocal interactions among academic, organizational, personal, and sociocultural contexts. Findings indicate that professional identity, at the beginning of a career, is shaped primarily by academic preparation and early workplace experiences that establish initial feelings of competence and belonging but also trigger credibility challenges and imposter syndrome. As women move into managerial roles, heightened exposure to bias, stereotype threat, and caregiving demands produces identity conflicts that complicate the integration of engineering, leadership, and personal roles. At the senior level, participants demonstrate more consolidated professional identities characterized by resilience, clarity of purpose, and salient leadership; they mentor others, assume influential roles in their organizations, and advocate for structural and cultural change. Although the small, context-specific sample limits generalizability, the results suggest the need for tailored curricular, training, and leadership development interventions at each career stage to support women engineers' identity formation, mitigate identity conflict, and strengthen inclusive leadership pathways in engineering.

Keywords: women in engineering, career stages, professional identity, training and leadership development

1. Introduction

Engineering as a profession is undergoing rapid transformation, with technological change, interdisciplinary collaboration, and problem-solving demands reshaping what it means to be an effective engineer. In this context, organizations increasingly recognize that sustained training, mentoring, and professional development are not supplementary but essential components of modern engineering careers (Litchfield et al., 2021). Engineers today must navigate complex organizational systems, communicate across diverse teams, and integrate technical expertise with leadership capacity. This evolving professional landscape has prompted scholars and industry leaders to emphasize leadership development, identity formation, and workplace learning as core elements of engineering career success (Nguyen et al., 2022).

Central to this developmental paradigm is the concept of professional identity, which shapes how engineers understand their role, purpose, and competence within the field. A well-established professional identity strengthens persistence, enhances motivation, and provides a foundation for leadership engagement (Fleming et al., 2020). Research shows that identity is not formed solely in school or at a single transition point; rather, it develops gradually through a combination of academic preparation, workplace learning, mentoring relationships, and increasing professional responsibility (Johnson et al., 2023; Limberg et al., 2013; Tonso, 2014). As a result, training programs across universities and industry settings increasingly embed identity-building experiences including project-based learning, industry placements, collaborative capstones, and technical leadership training to broaden engineers' sense of capability and belonging (Carberry et al., 2020).

Professional development also expands the range of career possibilities that engineers see for themselves. Leadership training, communication workshops, rotational programs, and competency-based development pipelines equip engineers to transition from technical contributors to project leads, managers, and technical strategists (Beddoes & Panther, 2022;

Liu et al., 2022). Such programs help engineers refine essential competencies, including decision-making, collaboration, conflict navigation, and systems-level thinking skills increasingly required in technology-driven organizations (Eraut, 2014). Mentoring, sponsorship, and coaching further reinforce these capacities by providing role modeling, reassurance, and opportunities to apply leadership principles in authentic contexts (Fuesting et al. 2023; McCullough 2020).

Within this broader developmental framework, women engineers experience training, mentoring, and identity construction in ways that shape their leadership trajectories, not merely as a response to barriers but as a proactive path toward career advancement. Numerous studies demonstrate that women benefit substantially from structured mentoring, leadership institutes, and professional development programs that integrate socio-emotional learning, technical skill advancement, and leadership identity building (Khan et al., 2024). This body of work suggests that such interventions strengthen confidence, reinforce professional belonging, and help women envision long-term leadership roles within engineering organizations. Training and development thus become mechanisms not only for expanding technical capability but also for cultivating agency, vision, and leadership readiness.

Moreover, workplace learning research highlights that engineers develop expertise and leadership capacity through iterative cycles of challenge, practice, reflection, and feedback (Billett, 2016). These cycles are embedded in everyday activities interactions with supervisors, participation in communities of practice, exposure to high-stakes projects, and opportunities for organizational contribution. Women develop leadership identities through scaffolded developmental experiences that validate their contributions and encourage broader participation in organizational decision-making (McCullough, 2020). When organizations intentionally link training, mentoring, and structured career pathways, women engineers gain access to the developmental ecosystem necessary for sustained leadership growth.

Further, professional identity formation requires more than technical mastery. Engineers benefit from developmental spaces that integrate affective, cognitive, relational, and identity-based learning. Programs designed to cultivate reflective practice, communication skills, and interpersonal awareness enhance engineers' ability to lead teams, negotiate conflict, and align technical goals with organizational and social priorities (Carberry et al., 2020; Nguyen et al., 2022). Identity-centered developmental ecosystems that combine formal training, mentoring, communities of practice, and leadership opportunities provide the conditions under which engineers can grow from novice practitioners to confident, influential leaders (Brunhaver et al., 2018). For women engineers, such integrated developmental systems are particularly consequential. Studies show that when women receive consistent mentoring, developmental feedback, leadership opportunities, and recognition, they not only stay in engineering at higher rates but also advance into roles of strategic influence (Dennehy & Dasgupta, 2017). Professional identity deepens not simply in their roles as technicians, but also as innovators, collaborators, mentors, and leaders. Training thus contributes to the emergence of leadership identity early in their career and its consolidation over time.

In sum, the literature suggests that training and development experiences are foundational to the construction of professional identity and leadership capacity. They represent the infrastructure through which engineers, especially women, gain confidence, refine competencies, broaden career imagination, and contribute meaningfully to organizational and societal innovation. This study builds on this developmental perspective by examining how women engineers construct professional and leadership identities across career stages through training, mentoring, and organizational experiences. Rather than framing women's advancement primarily in terms of overcoming inequities, this study emphasizes developmental trajectories, capacity-building, and the long-term cultivation of leadership potential within engineering.

1.1 Theoretical Framework

This study examines how women engineers construct and develop their professional identity across different career stages, drawing on two complementary theoretical perspectives. Professional identity theory provides a framework for understanding how individuals integrate knowledge, skills, and values to form a coherent sense of self within a profession, while Social Cognitive Career Theory (SCCT) highlights the role of self-efficacy, outcome expectations, and contextual supports in shaping career development and persistence. Together, these perspectives offer a lens for exploring how training, mentoring, and workplace learning experiences influence the processes of identity formation, resilience, and advancement in engineering careers.

Professional identity is generally recognized as an individual's self-perception and sense of affiliation with their profession, influenced by their experiences, personal values, and engagements within their professional environment. It extends beyond technical expertise in that it supports the development of equanimity to confront dominant organizational norms and overcome various personal challenges (Kaplan & Flum, 2012). It has been explored extensively across fields such as medicine, counseling, nursing, law, and teacher education, where professionals adopt identity frameworks suited to their specific professional roles and commitments (Kaplan & Flum, 2012). Trede et al. (2012) explained that professional identity emerges through a developmental process in which individuals actively participate in their field, integrating self-concept

with their professional philosophy and connecting with colleagues both within and outside their discipline.

Professional identity theory emphasizes how individuals develop a coherent sense of self within a profession by integrating knowledge, skills, values, and norms into their personal and professional lives. For engineers, professional identity reflects not only technical competence but also recognition, belonging, and legitimacy within academic and workplace communities. Prior studies suggest that professional identity serves as an anchor, enabling individuals to persist in the face of challenges and to envision long-term career trajectories. In this study, professional identity theory provides a foundation for understanding how women engineers construct meaning from their training, mentoring, and career development experiences, and how these experiences shape their evolving sense of competence and purpose across career stages.

From a career development perspective, we applied *social cognitive career theory* (SCCT) to identify major contextual factors, such as sociocultural, personal, and organizational, that interact with environmental influences in shaping individuals' career progression in engineering. Originally developed by Lent et al. (1994), SCCT offers a comprehensive framework for understanding the dynamic processes of career development (Damodar et al., 2024; Wendling & Sagas, 2020). Lent et al. (2000) further expanded the theory by introducing three interconnected models to explain how career development unfolds: the interest model, which describes how academic and vocational interests develop; the choice model, which explains how individuals make educational and career decisions; and, and the performance model, which addresses how individuals demonstrate competence. SCCT has been widely applied to studies of workforce development and has introduced the concept of proximal environmental factors, which include organizational influences such as mentorship, inclusive climates, and access to resources (Lapan & Smith, 2023). These supports and barriers directly affect self-efficacy and career persistence and play a critical role in shaping leadership identity and long-term professional growth. Conversely, factors such as workplace bias, lack of mentorship, financial constraints, or limited career opportunities can suppress self-efficacy and hinder career advancement; because these factors are short-term and context-specific, they may either facilitate or impede individuals' leadership identity and professional development.

This framework has been widely adopted in engineering research to examine women's career interests, decisions, and success (Canney & Bielefeld, 2020; Jung & Kim, 2020; Sebastián-Tirado et al., 2023). SCCT has been especially useful for analyzing how contextual conditions shape access to and success in engineering careers. In particular, researchers have drawn on SCCT's career choice model because it explicitly incorporates environmental supports and barriers as factors that influence individuals' decisions and ultimately their career outcomes in engineering (Cannady et al., 2017; Desing et al., 2024). For instance, Martin et al. (2008) found that social barriers negatively correlate with women engineering students' sense of belonging and engineering career goals. These findings illustrate that contextual affordances are not simply background conditions but active forces that shape how women imagine and pursue engineering futures.

In this way, SCCT complements professional identity theory by explaining the dynamic processes of career development through three key constructs: self-efficacy beliefs, outcome expectations, and personal goals. It emphasizes that individuals' confidence in their capabilities and their expectations about career outcomes are central to persistence and success. Supportive environments such as effective mentoring, leadership development programs, and recognition within professional networks can enhance career growth, whereas unsupportive contexts may undermine it. In the context of engineering, SCCT provides a lens for examining how career development opportunities interact with personal agency to influence women's persistence, advancement, and leadership pathways.

1.2. Current Study

This study is conceptually grounded in social cognitive career theory (SCCT) and professional identity theory and examines how women engineers construct and develop their professional and leadership identities across career stages within training- and work-based contexts. Building on prior research that links training, mentoring, and workplace learning to career advancement, we focus specifically on how engineering identity, leadership identity, and organizational enculturation develop through developmental experiences. SCCT provides a framework for understanding how self-efficacy, outcome expectations, and contextual supports and barriers shape women engineers' persistence, advancement, and leadership pathways (Desing et al., 2023; Tal et al., 2024, while professional identity theory explains how engineers integrate knowledge, skills, and values into a coherent sense of self in the profession (Lowe et al., 2025; Nudelman, 2017; Vo et al., 2024).

Guided by these frameworks, this study adopts a comparative, developmental perspective to examine how women engineers at junior and senior stages describe their training experiences, workplace learning, and leadership opportunities, and how these experiences influence their professional identity formation. The study identifies which influences are consistent across stages (for example, mentoring, recognition, and self-efficacy) and which are specific to particular career phases. By shed light on the developmental trajectories of women engineers, the study identifies which influential factors are universally important, which are career-stage specific, and how professional identity evolves over time. The resulting model informs the design of career-stage specific training, mentoring, and professional development systems that enhance women engineers' self-efficacy, professional identity, leadership development, and long-term career sustainability.

2. Method

In this study, grounded theory was used for capturing dynamic, evolving central phenomena professional identity. It allows the analysis to reveal emerging patterns and distinctions across career stages rather than imposing preexisting assumptions. Through iterative coding and constant comparison, the inquiry examines how workplace learning, leadership training, structured mentoring, and recognition within professional networks contribute differently to identity development for junior versus senior engineers. This analytic approach enables the study to generate a process-oriented, comparative model that illustrates: Distinct developmental needs at career stages, the mechanisms through which professional identity is shaped, challenged, or reinforced across these stages, how beginning/junior engineers' identity-building strategies differ from the identity consolidation of senior engineers, and the types of training, mentoring, and organizational supports most effective for each stage of professional growth. Grounded theory is particularly suited for exploring complex, contextually embedded phenomena and allows for developing conceptual models in participants' experiences (Strauss & Corbin, 1990). This methodology supports the development of grounded, stage-specific conceptual models that illuminate the evolving nature of the central phenomena and ensured capturing deeply rooted participants' narratives (Bryant & Charmaz, 2007). It enabled iterative concurrent data collection and analysis and facilitated the identification of emergent themes and patterns to create conceptual models.

2.1 Data Collection and Procedures

This study was reviewed and approved by the Institutional Review Board of the authors' institution. All participants provided informed consent prior to participation and were informed of the study's purpose, procedures, voluntary nature, and confidentiality protections. Participants were assured that they could withdraw from the study at any time without penalty, and all data were anonymized to protect participants' identities. A total of 21 participants were recruited across the various career stages in engineering through snowballing method. They were categorized into two groups, junior and senior based on their tenure and each stage's developmental milestones and responsibilities in the engineering profession. Participants were drawn from various engineering disciplines, including electrical, mechanical, and aerospace engineering (see Appendix A). Initial online interviews lasted approximately 60 minutes, and, as necessary, 30 minutes of follow-up online or phone interviews were conducted for member checking (see Appendix B for sample interview questions). All sessions were audio-recorded and transcribed.

2.2 Participants Characteristics

The study included 21 women engineers (11 at junior and 10 at senior career stage), with work experience ranging from less than one year to more than 30 years. Participants were initially recruited through professional engineering networks and women-in-engineering associations using purposive sampling, followed by snowball sampling to identify additional participants. Recruitment occurred across two sampling waves and continued until thematic saturation was reached. Participants held bachelor's, master's, and doctoral degrees (including one MBA) across disciplines such as mechanical, civil, aerospace, electrical, computer, industrial, and multidisciplinary engineering. Participants were categorized by career stage based on years of professional experience: those with fewer than 15 years of engineering experience were classified as junior engineers, including early- to mid-career professionals, whereas those with 15 years or more of experience were classified as senior engineers. The sample was ethnically diverse and represented a wide age range and varied family situations, offering diverse perspectives on how marital and caregiving responsibilities intersect with engineering careers (see Appendix 1.)

2.3 Data Analysis

Data analysis followed a systematic coding process consisting of open, axial, and selective coding (Creswell, 1998). First, open coding involves breaking the data into discrete components to identify and label emerging themes and reveal key themes and influencers. Next, axial coding was employed to establish connections between the identified themes, organizing them into relational categories such as causal conditions, contextual factors, and intervening conditions. It provides a structured framework for understanding the developmental process (Strauss & Corbin, 1990). Finally, selective coding was used to integrate and refine the analysis, focusing on core phenomena that encapsulated the essence of the central phenomena to develop a cohesive conceptual model (Bryant & Charmaz, 2007). This coding process ensured that the analysis remained grounded in participants' experiences, facilitating the development of a context-sensitive framework. Social Cognitive Career Theory (SCCT) directly informed coding and interpretation in this study. Its core constructs including self-efficacy, outcome expectations, and contextual supports and barriers guided the organization of codes, category development, and comparative model building across career stages. This theoretical grounding supported coherent interpretation of professional identity development patterns and strengthened the explanatory power of the final model. To enhance trustworthiness, we addressed credibility, dependability, confirmability, and transferability throughout the study. We conducted member checking to validate participants' interpretations, engaged in peer debriefing and maintained an audit trail to support analytic rigor, and practiced ongoing researcher reflexivity during data collection and analysis to enhance transparency and minimize bias.

3. Findings

The analysis revealed a progressive process of professional identity development that varied across two different career stages. Women engineers described how training, mentoring, and workplace learning shaped their sense of competence, belonging, and leadership capacity. The findings are presented in two main parts: (1) the development of professional identity during the junior career stage is highly formative and is shaped by professional development training, engineering project experiences, and organizational enculturation processes, and (2) the experiences of senior engineers, where professional identity becomes more consolidated, characterized by socio-cultural influences, organizational leadership practices, and mentoring roles.

3.1 Professional Identity Development for Junior Engineers

For junior engineers in the early and mid-career stages of their careers, professional identity formation was closely tied to engineering education, engineering project achievements, and the quality of onboarding and early professional development experiences. These opportunities fostered initial self-efficacy and a sense of belonging within the engineering organization. As participants were promoted to managerial levels, professional identity development became more complex. Participants highlighted the importance of structured leadership development, networking, and coaching in navigating organizational cultures and advancing promotion goals, which contributed to the development of their professional identity as engineering professionals. Further, organizational context played the most substantial role in shaping their professional identity, influencing their ability to integrate engineer, leadership, and personal identities (see Figure 1).

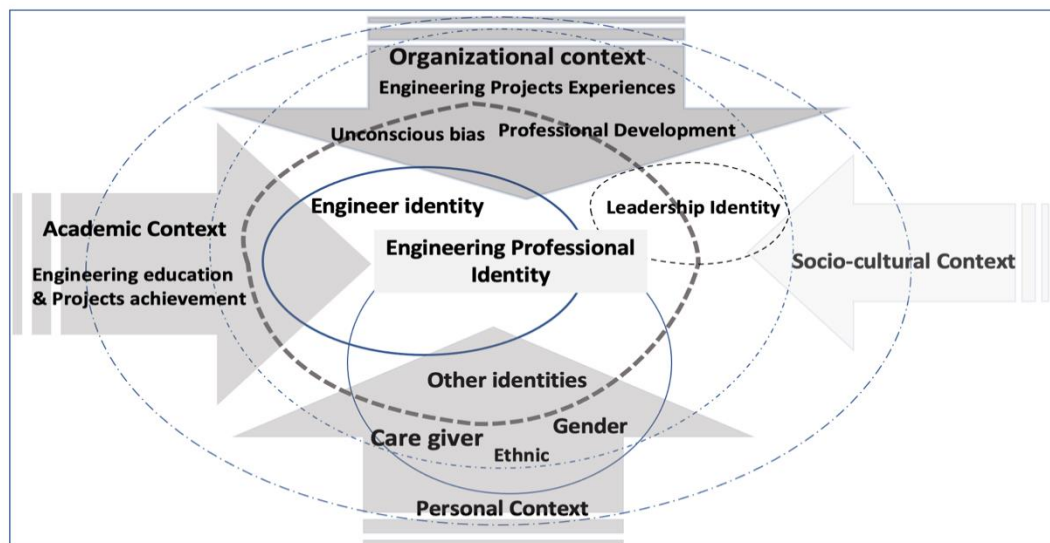


Figure 1. The model of professional identity development at the junior level

While early workplace training established a foundation, participants later faced socio-cultural pressures, including unconscious bias that they increasingly perceived as systemic discrimination. These experiences intensified the need to develop resilience and equanimity to navigate organizational systems. Without such capacities, intentions to leave the organization or consider a career change became more frequent. The model above illustrates this multifaceted professional identity development process. As participants became more deeply enculturated into their engineering profession and organizational environments, their other identities became strongly intertwined with professional identity development at this stage. However, ongoing professional development training, specialized knowledge acquisition, and the practical application of engineering skills further solidified their professional identity as engineers.

E1: In the beginning, my confidence really came from doing well in school and being trusted with technical projects. When my manager took time to explain how my work fit into the larger engineering goals, I started to feel like I truly belonged here as an engineer.

As they gained more experience, their technical expertise, leadership responsibilities, and personal identities (e.g., gender and ethnicity) became increasingly interconnected, forming a more cohesive professional identity as engineers. While technical expertise remained central to their professional identity, many participants recognized the growing importance of leadership. Initially, they believed that being a great engineer was solely about technical mastery. However, they came to see that various leadership competencies including project management, communication, and decision-making were critical as they progressed.

E2: After a few years, the job was no longer just about solving technical problems. I had to learn how to lead meetings, communicate across teams, and advocate for myself. Leadership training and mentoring were critical in helping me see myself not only as an engineer, but as someone capable of managing people and projects.

Simultaneously, the organizational context became increasingly prominent, shaped by professional achievements, career progression opportunities, and experiences in workplace leadership. Participants perceived unconscious bias and stereotype threat as they advanced, which significantly hindered their professional identity development and career advancement significantly. As they navigated and overcame these obstacles, participants gradually developed a stronger, more integrated professional identity as engineers and leaders.

As they advanced in their careers and gained recognition as leaders within their organizations, they found that their engineer and leadership roles were not separate but rather interconnected aspects of their evolving identity. As they continued to progress, they recognized that understanding organizational culture was as important as technical problem-solving.

E3: The culture of the organization really shaped how I saw myself. In environments where leadership valued inclusion, it was easier to integrate who I am as a woman with my role as an engineer and a leader. In less supportive contexts, those identities often felt fragmented. In a leadership meeting, I offered an idea and no one responded. A few minutes later, a male colleague repeated it, and everyone praised it as a great idea. I remember feeling deeply frustrated and unseen.

In addition, the personal context highlights intercorrelations among identities by explicitly recognizing identities beyond gender and ethnicity, notably introducing caregiving roles. The inclusion of a caregiver identity points out the distinct challenges junior-level women engineers encounter, such as managing demanding professional responsibilities alongside personal and familial obligations. Building on these intersecting demands from different roles, participants reflected on key career milestones, including leading engineering projects, developing products, earning managerial promotions, and navigating motherhood. While these achievements reinforced their professional identity as engineers, many struggled with imposter syndrome, particularly those juggling career advancement and caregiving responsibilities. The pressure to excel in both domains often led to self-doubt and exhaustion, making it difficult for them to feel entirely successful in either role.

E4: There were moments when I seriously questioned whether staying in engineering was worth it. When I felt rigid and unsupportive, leaving the company or even the field itself felt like the best option. For now, I am postponing having a baby to finish my current projects, but I am not confident I will still be given project leadership after returning from maternity leave.

E5: Becoming a mother changed how I understood myself as an engineer and a leader. I became more intentional about how I managed my time and more empathetic in how I led others. In some ways, caregiving strengthened my leadership skills, but it also made me more aware of organizational expectations that were not designed with family responsibilities in mind. When the workplace recognized and supported this part of my identity, I felt more committed and confident. When it did not, balancing my professional and personal identities became significantly more challenging.

Finally, socio-cultural influences persist as overarching external pressures impacting professional identity formation. Societal expectations regarding gender roles, social responsibilities, and leadership capabilities significantly shape junior-level women engineers' experiences and opportunities. These influences can reinforce traditional barriers or catalyze progressive shifts in professional norms, profoundly affecting women's self-perception and professional trajectories.

E6: As I gained more experience and completed advanced training, my professional identity became stronger. Applying specialized knowledge and seeing the impact of my work helped solidify my confidence as an engineer, even when other parts of my identity were evolving. I am proud of myself as a working mom supporting my family, including two young children, and I see myself as an emerging leader in my company after being invited to a leadership program.

E7: Early on, I didn't always recognize bias, but over time patterns became clearer. Small comments and unequal expectations made me more aware of systemic barriers. I tried not to take these experiences too personally and had to develop emotional resilience just to keep moving forward and not internalize those experiences.

Together, these findings illustrate the complexity of professional identity development for junior women engineers and emphasize the need for supportive organizational cultures that recognize and accommodate the ongoing negotiation of multiple identities centered on their engineer identity. The integrative model demonstrates how academic preparation, workplace learning, caregiving responsibilities, and socio-cultural expectations intersect to shape both vulnerability and growth at this career stage. Building on this foundation, the senior-level stage represents a more advanced phase in which professional identity is well-established and leadership becomes increasingly prominent, as women engineers mentor others, influence organizational practices, and actively contribute to shaping engineering culture.

3.2 Professional Identity Development for Senior Engineers

Compared with the junior career stage, women engineers at the senior level demonstrated a stronger and more consolidated professional identity, having effectively navigated earlier career challenges and deeply internalized their leadership roles within both their organizations and the broader engineering community. They described leadership as advocacy, sponsorship, and the ability to transform organizational cultures. As shown in Figure 2, leadership identity development became particularly prominent as they transitioned from technical experts to roles involving broader organizational influence and strategic leadership.

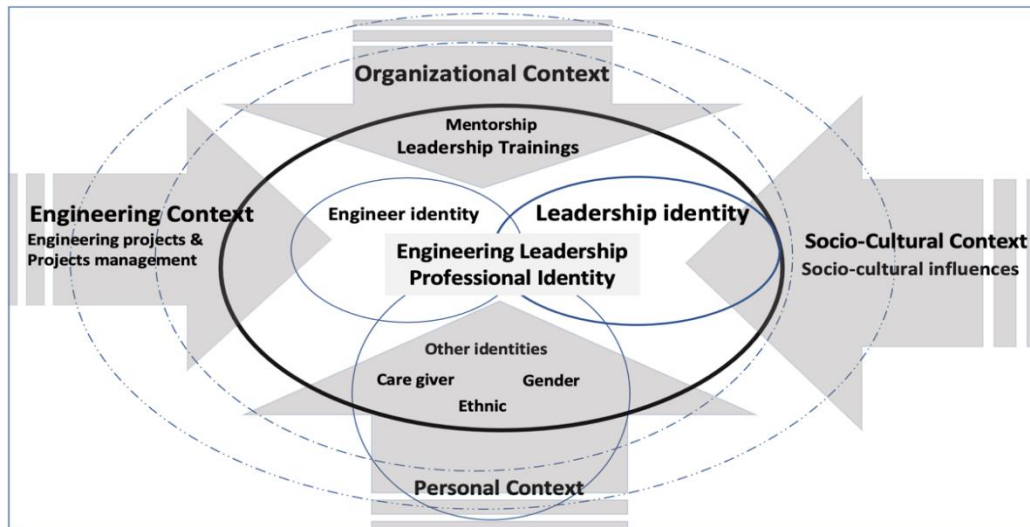


Figure 2. The model of professional identity development at the senior level

Organizational context significantly influenced participants' professional identity, reflecting cumulative project achievements and extensive engineering training experiences that served as the foundation for their leadership roles. Many participants also credited leadership development programs, executive coaching, and organizational training initiatives as critical resources that helped them refine their leadership styles and expand their capacity to influence others. As they advanced in their careers, they acquired a range of leadership competencies that extended beyond technical expertise. These competencies included strategic communication, decision-making under pressure, mentorship and talent development, conflict resolution, and the ability to influence organizational culture. Many participants emphasized that these skills were not innate but developed progressively through training programs, mentoring experiences, and project leadership opportunities. These leadership competencies also involved cultivating emotional intelligence and resilience, enabling senior women engineers to navigate complex organizational dynamics while maintaining credibility and authority.

A1: When I first got a leadership title without “engineer” in it, I felt confused about my role because I had always been introduced as an engineer. Later, I realized that years of working on complex engineering projects had already given me a strong sense of credibility. That technical foundation is what allows me to speak with confidence, challenge assumptions, and make decisions that others trust. Even now, my leadership is grounded in my identity as an engineer first.

The development of leadership competencies and professional identity seems deeply interconnected, with each reinforcing as they move to different career stages. Participants also shared effective strategies to mitigate or manage personal and organizational challenges, including biases, while strengthening their resilience and equanimity in ways that enhanced their leadership identity. In the organizational context, participants learned to stay composed in adversity, using strategic advocacy to advance their careers. Over time, they recognized that leadership extended beyond technical expertise to include advocacy, mentorship, and shaping workplace culture. Several described how formal leadership training, peer-learning cohorts, and professional development workshops provided structured spaces to reflect on their experiences and translate them into actionable leadership practices.

A2: Moving into leadership required more than experience; it required learning how organizations actually function. Leadership training, executive coaching, and senior roles helped me understand how to influence systems, not just projects. Over time, I stopped seeing leadership as separate from engineering and began to view it as an extension of my professional responsibility.”

A3: I used to think leadership was just about making the right technical decisions. But as I moved into senior roles, I realized leadership is about mentoring, empowering, and setting the stage for others to succeed. Now, I prioritize

supporting younger engineers, especially women, because I want to be the leader I wished I had when I was starting out. I think my professional identity shifted from being an engineer to a leader as I develop my career in Engineering.

The personal context emphasized intersectionality by explicitly recognizing identities beyond gender and ethnicity, notably introducing family roles alongside professional identity. As they advanced in their careers, they grappled with balancing personal and professional roles. They cultivated multifaceted identities including engineer, leader, and caretaker that consolidating them into a cohesive professional identity. They mentioned about leadership training opportunities and organizational workshops on inclusive management further helped participants navigate these competing demands by providing strategies for communication, delegation, and balancing responsibilities.

A4: At the core of who I am, I'm an engineer. My technical expertise and the projects I've led over the years define my career; but I've also evolved into a leader, mentor, and mother. Balancing these roles hasn't always been easy... my confidence in my engineering abilities is what kept me grounded. When I see my designs become reality and hear my peers recognize me as a leader, I know I belong in this field.

A5: At this stage of my career, I no longer feel that I have to prove myself or separate who I am from how I lead. My personal values, life experiences, and responsibilities inform my leadership style. Rather than weakening my professional identity, they have strengthened my clarity, judgment, and commitment as an engineering leader.

Participants also highlighted that how continuous training opportunities such as executive coaching, innovation workshops, and professional leadership institutes broadened their perspectives on leadership. These structured programs often served as turning points, shifting their identity from being primarily technical experts to being recognized as leaders.

Societal expectations also significantly shaped participants' leadership identity as a core dimension of their professional identity. However, they typically possessed greater influence and agency to challenge and alter these perceptions, often supported through executive training, mentoring programs, and organizational leadership initiatives. Over time, they developed multifaceted professional identity, integrating engineering expertise, leadership skills, and personal responsibilities.

A6: As my career progressed, my role expanded beyond my organization. I began contributing to industry groups, advising public initiatives, and mentoring across institutions. I now see leadership as having a societal dimension, where engineering expertise can influence policy, equity, and long-term impact. I am also considering teaching a course at a community college and meeting future engineers after retiring from my current job in a few years.

Senior women engineers described a more integrated and consolidated professional identity, reflecting both engineering expertise and leadership responsibility. Whereas beginning and junior engineers primarily focused on establishing technical credibility, demonstrating competence, and gaining acceptance within organizational hierarchies, senior engineers articulated an identity that extended beyond individual performance. Their leadership identity was no longer defined solely by technical mastery but encompassed mentoring junior colleagues, nurturing team development, and actively shaping inclusive and supportive workplace cultures. In contrast to participants earlier in their careers, who often experienced tension between professional expectations and caregiving responsibilities, senior participants reframed caregiving, mentoring, and relational work as integral to their leadership approach. These responsibilities were viewed not as competing demands but as sources of insight, empathy, and legitimacy that strengthened their leadership identity. This comparative pattern clarifies how professional identity evolves across career trajectory and distinct developmental needs, challenges, and supports characterize women engineers' professional identity from technical self-establishment to relational and organizational leadership.

4. Discussion

The present study reframes women engineers' career development not only as a matter of retention, promotion, or advancement but as an ongoing process of cultivating a self-actualized professional identity within the engineering field. Rather than treating women's career progression as a linear pathway, this study foregrounds the dynamic, iterative processes through which professional identity and leadership capacity are formed, negotiated, and strengthened over time. In this sense, career development is better understood as a leadership trajectory that is shaped by early training experiences, mentoring relationships, organizational culture, and cumulative professional experiences, in line with prior work on workplace learning and professional growth in engineering (Litchfield et al., 2021). Empirical work has shown that professional identity is closely tied to motivation, persistence, and leadership engagement (Fleming et al., 2020; Matusovich et al., 2014), the present findings further indicate that women engineers' personal growth, self-efficacy, resilience, and leadership-building as central components of their professional identity development. Participants were not passive respondents to organizational structures and cultures; they actively interpreted, resisted, and reshaped their identity in the workplace. This orientation aligns with literature on identity work and leadership development in engineering and STEM more broadly, where identity is constructed through practice, reflection, and social interaction

(Komives et al., 2005; Tonso, 2014; Ibarra et al., 2010). Such an approach deepens our understanding of women's experiences in engineering while providing critical implications for designing professional development programs, mentoring structures, and organizational practices that intentionally cultivate confident, influential, and adaptive leaders in the engineering workforce.

The conceptual developmental models in this study provide a holistic account of women engineers' career trajectories. They reveal the intertwined effects of career motivation, attrition, contextual barriers, possible accommodations, and they identify leverage points for training and organizational interventions that support sustainable professional growth. In line with Social Cognitive Career Theory (SCCT), the findings illustrate how personal inputs, background affordances, and contextual supports and barriers collectively shape self-efficacy, outcome expectations, and career-related choices over time (Lent et al., 1994; Sheu et al., 2010). The results also resonate with studies that show how social and structural conditions influence women's access to and success in engineering careers (Canney & Bielefeld, 2020; Lin & Deeme, 2021). Within this SCCT frame, women engineers' professional identity development appears as both constrained by institutional conditions and enabled by developmental opportunities such as mentoring, leadership training, and communities of practice (Carberry et al., 2020). The SCCT provides a robust lens for understanding how women navigate systemic constraints, shifting power dynamics, and institutionalized gender norms as they work to define themselves as engineers and leaders. Women engineers often begin their careers by concentrating on demonstrating technical competence and establishing credibility. As they move into more advanced roles, they increasingly rely on mentoring, coaching, and workplace learning to consolidate confidence, navigate organizational expectations, and expand their influence. Across roles and years of experience, professional identity development, especially the sense of belonging, legitimacy, and purpose, forms the backbone of persistence and long-term leadership potential. The conceptual model illustrates the dynamic interplay among personal inputs (e.g., gender), background affordances (e.g., education), and workplace experiences in shaping women engineers' continuous negotiation of professional legitimacy. Across roles and years of experience, their identity development is not linear or uniform but an evolving interaction between personal strengths, institutional constraints, and opportunities for leadership growth. It shows that understanding women engineers' leadership trajectories thus requires moving beyond descriptive accounts of underrepresentation. Instead, it calls for the developmental conditions that foster resilience, self-efficacy, influence, and sustained engagement with the profession. This perspective allows for deeper insight into how organizational climates, developmental supports, and personal agency converge to shape women's paths in engineering. It responds to calls for more generative research approaches that foreground growth, capability, and leadership development as central to women's advancement (Fouad & Singh, 2011; Lin & Deeme, 2021).

The findings also show that experiences in the transition from education into professional practice are especially formative. Aligned with prior literature, women described entering environments where technical competence was implicitly assumed for men but questioned for women (Moss-Racusin et al., 2012). This dynamic compelled many early-career women engineers to continually validate their expertise, often at significant emotional and cognitive cost. At the same time, positive reinforcement, early accomplishments, and supportive mentorship were powerful counterweights that strengthened self-efficacy and helped solidify emerging professional identity (Settles et al., 2016). This transition highlights the importance of inclusive onboarding practices, structured mentorship, early leadership training, and institutional mechanisms that explicitly affirm women's technical competence. Such supports enhance individual persistence and contribute to more equitable leadership pipelines over time (Khan et al., 2024). It shows that professional identity development emerges here as a site of struggle, resistance, and transformation. It aligned with Hatmaker (2013) who described women engineers' evolving identities reflect ongoing negotiations with exclusionary norms and gendered expectations embedded within engineering culture. Their persistence represents far more than individual achievement; it symbolizes their active participation in reshaping the profession. As they advance, many assume mentorship roles, lead affinity initiatives, and advocate for inclusive practices, extending their leadership beyond personal success to elevating and empowering future generations of women engineers. Viewed through this lens, professional identity development can be understood as an ongoing process of contestation and change rather than a fixed end state. Women engineers' evolving identities are shaped by continual negotiations with exclusionary norms and gendered expectations embedded within engineering culture. Their persistence therefore signifies more than individual success; it reflects active engagement in transforming the profession itself. As they advance, many take on mentorship roles, lead affinity initiatives, and advocate for inclusive practices, extending their leadership beyond personal advancement to elevate and empower future generations of women engineers.

A key distinction emerging from the findings lies in the developmental differences between women who are still consolidating their roles in organizations and those who have reached senior positions. Women in earlier phases of their careers reported heightened scrutiny and resistance from organizational authority figures, which required them to strategically assert technical competence while simultaneously learning the informal norms and expectations. Their

identity development was often marked by tension and fragmentation, as they were still forming confidence, internalizing workplace culture, and negotiating how their gender, ethnicity, and caregiving responsibilities intersect with their engineering identity. Often established identities conflict as they had to balance external pressures for conformity with internal aspirations for authenticity, particularly around what “acceptable” leadership should look like for women in engineering (Cook & Glass, 2013).

For senior women engineers, they demonstrated a more fully integrated and consolidated leadership identity as their professional identity. By this point of their career, they had mastered technical skills and leadership competencies and had also internalized a strong sense of professional legitimacy. Their personal identities and professional roles tended to reinforce, instead of competing with, one another. Their leadership was characterized by greater autonomy, authority, and a future-oriented perspective. Rather than defending their place within the profession, they focused on transforming it by mentoring younger engineers, shaping organizational policies, and advocating for inclusion. Their experiences reflected a shift from survival to influence, from reactive coping to proactive shaping of professional culture. They were no longer negotiating legitimacy for themselves; they were producing legitimacy for others by altering norms, challenging biases, and expanding what leadership looks like in engineering. Their presence underscores the long-term impact of cultivating women’s leadership pipelines. These patterns support research showing that when women reach higher levels of authority, they can leverage their positions to challenge exclusionary norms and foster more inclusive communities of practice. From a professional identity perspective, this phase represents not only identity consolidation but also identity generativity, in which leaders invest in the development of others and in the transformation of the profession itself.

It shows that the professional identity development for women engineers is not by accomplishing a single milestone, but a cumulative and developmental process shaped by repeated cycles of challenge, feedback, and recognition of achievements. As women move into roles with greater responsibility, they must maintain technical credibility while increasingly being evaluated on leadership capacities such as communication, team coordination, and strategic decision making (Nguyen et al., 2022). As previous research has indicated, participants described relying on mentorship, sponsorship, and structured professional development to build confidence, navigate performance expectations, and expand their influence (Buse et al., 2013). These results support existing evidence that leadership institutes, peer mentoring, and developmental feedback can strengthen women’s leadership identity and sense of belonging in engineering. At the same time, the study highlights the persistent impact of gendered organizational norms and identity threats. Women described needing to prove their technical competence and leadership legitimacy more often than male colleagues, a pattern that echoes work on implicit bias, stereotype threat, and gendered expectations in STEM workplaces (Hall et al., 2015; Khan et al., 2024). These experiences contribute to imposter feelings and identity conflict, particularly for those managing caregiving responsibilities alongside leadership roles, which is consistent with research on role conflict and identity interference among women in STEM (Settles et al., 2016). Within an SCCT perspective, such conditions operate as contextual barriers that can depress self-efficacy and limit perceived career options. The present findings extend this work by showing how women respond through strategic coping, boundary management, and selective engagement in developmental opportunities, thereby converting some constraints into catalysts for growth.

In conclusion, this holistic, professional identity-centered perspective provides a framework for understanding how women engineers construct enduring careers and leadership identities within a profession historically resistant to gender equity. As an implication, human resources professionals and organizational leaders should consider how different phases of professional identity development call for distinct forms of support. Organizational practices should provide structured opportunities for women to exercise influence and act as mentors, while also receiving sponsorship and recognition themselves. By strategically tailoring support and development initiatives to different points along the professional identity trajectory and by incorporating an intersectional lens on power structures and career resilience, organizations can more effectively foster the consolidation of professional and leadership identities among women engineers.

5. Limitations and Future Study

This study has several limitations that should be acknowledged. First, the sample size and engineering fields were limited, restricting the generalizability of the findings. Second, researcher positionality may have influenced data collection and interpretation. Although reflexivity strategies were employed to minimize bias, the interpretation of findings is inherently shaped by the researchers’ backgrounds and perspectives. Future studies should explore how intersecting identities impact career development, professional identity formation, and leadership experiences in engineering. To build upon these findings, future research should employ longitudinal and quantitative methodologies to examine how women engineers’ professional identity evolves. This study can track women engineers at different career stages could reveal patterns in identity consolidation, self-efficacy development, and career persistence. Using survey-based scales measuring self-efficacy, leadership identity, imposter syndrome, and workplace inclusion, it will reveal trends and patterns in identity consolidation and barriers faced. Additionally, a quantitative intersectional approach could investigate how race, ethnicity, caregiver status, and socioeconomic background shape professional identity development. A multivariate regression

analysis could determine whether specific demographic factors contribute to higher levels of imposter syndrome or resilience in the profession.

Acknowledgments

Not applicable.

Authors contributions

Dr. Park M. was responsible for study design, data collection, and draft the manuscript. Dr. Park J. contributed to analyze data and design conceptual models and revise the manuscript. All authors read and approved the final manuscript. In this paragraph, also explain any special agreements concerning authorship, such as if authors contributed equally to the study.

Funding

Not applicable.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Redfame Publishing.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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Appendix A. Participants Information

Participant	Work Experience	Engineering Majors	Degree level	Ethnicity	Age	Marital Status/Child
J1	1.6 yr	Computer engineering	BS	White	Mid 20's	Single
J2	1 yr	Civil engineering	BS	White	Mid 20's	Single
J3	2 yrs	Civil engineering	BS	Asian	Mid 20's	Single
J4	5 yrs	Civil engineering	BS	White	Mid 30's	Married/no child
J5	5.5 yrs	Aerospace engineering	Ph.D.	White	Mid 30's	Single
J6	6 yrs	Civil engineering	BS	Asian	Late 30's	Single
J7	8 yrs	Aerospace engineering	MS	Hispanic	Late 30's	Married/one child
J8	10 yrs	Mechanical engineering	BS	White	Mid 30's	Married/one child
J9	12 yrs	Industrial Engineering	MS	White	Late 30's	Single
J10	12 yrs	Mechanical engineering	MS	White	Early 40's	Married/two children
J11	13 yrs	Industrial engineering	Ph.D.	Asian	Early 40's	Divorced/one child
S1	17 yrs	Mechanical engineering	Ph.D.	White	Late 40's	Married/no child
S2	18 yrs	Mechanical engineering	BS	White	Mid 40's	Married/one child
S3	19 yrs	Industrial engineering	MS	Asian	Mid 40's	Single
S4	20 yrs	Electrical engineering	MBA	White	Mid 40's	Married/two children
S5	22 yrs	Aerospace Engineering	MS	Asian	Late 40's	Married/one child
S6	22 yrs	Civil engineering	MS	White	Early 50's	Married/two children
S7	25 yrs	Aerospace engineering	Ph.D.	White	Early 50's	Married/two children
S8	28 yrs	Civil engineering	MS	White	Mid 50's	Divorced/one child
S9	32 yrs	Aerospace engineering	MS	White	Late 50's	Married/three children
S10	33 yrs	Mechanical engineering	Ph.D.	White	Late 50's	Divorced/no child

Appendix B. Sample Interview Questions*Junior Women Engineers*

How would you describe your professional identity as an engineer at this stage of your career?

How have your education and early engineering projects shaped your sense of yourself as an engineer?

What organizational supports or barriers have most influenced the development of your professional identity so far?

How do your current experiences shape your expectations about advancement and your future professional identity in engineering?

How do personal and socio-cultural factors, such as life roles or workplace bias, influence your professional identity and motivation to remain in engineering?

Senior Women Engineers

How would you describe your professional identity as an engineer and leader at this stage of your career?

How has your technical engineering background contributed to the development of your leadership identity?

How did leadership roles, training, or coaching influence the evolution of your professional identity over time?

How are your personal values and life experiences integrated into your professional and leadership identity?

In what ways does your professional identity extend beyond your organization to influence the engineering profession or broader society?