




Exploring The Engineering Identity of Female Students in the Selection of Engineering Careers in Higher Education

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ABSTRACT

Women remain underrepresented in engineering—particularly in civil engineering—despite increased enrolment in higher education. This study examines how an engineering identity lens can inform fairer, more effective pre-admission decisions for female applicants. Framing identity through the Godwin/Hazari model—Interest, Recognition, and Performance/Competence (IRP)—and situating learning experiences within Holland’s RIASEC typology (with emphasis on Realistic–Investigative–Conventional, R-I-C), we conducted semi-structured interviews with seven industry and academic experts and applied thematic analysis. Experts affirmed the relevance of R-I-C for engineering task environments and refined these dimensions into five operational attributes suitable for screening candidates who may lack prior project experience: (1) Hands-On Technical Orientation, (2) Analytical & Evidence-Based Reasoning, (3) Standards, Codes & Documentation Discipline, (4) Engineer Self-Concept & Recognition Exchange, and (5) Societal & Sustainable Impact Orientation. These attributes explicitly link typical engineering activities to identity mechanisms that are especially salient for women in male-dominated settings—building early mastery and efficacy (R, I), making professionalism auditable (C), strengthening inclusion via proximal recognition (Self-Concept/Recognition), and aligning purpose with practice (Societal/Sustainable Impact). These propose an identity-informed, diagnostic (not exclusionary) pre-admission instrument based on the five attributes, coupled with structured mentoring and short bridge modules aligned to R-I-C. This integrated approach offers HEIs a practical pathway to surface genuine interest, readiness to learn, and support needs at entry, thereby improving retention and the longer-term representation of women in civil engineering. The study contributes a theory-grounded, practice-ready framework that operationalises engineering identity for selection and early support in higher education.

Keywords: Engineering Identity, Women in Engineering, Civil Engineering, HEI

INTRODUCTION

In recent decades, engineering has been recognised as one of the most crucial fields for human development. It has the potential to add value to products, processes, and services that contribute to economic development and improve the quality of life. However, despite its significance, the representation of women in engineering, especially in civil engineering, remains low (Dabic et al., 2024). This disparity is evident in many countries, including Malaysia, where the proportion of female engineers in the workforce lags far behind that of male engineers. Understanding

the factors that influence female students' decisions to pursue civil engineering and their long-term engagement in the field is essential for addressing this gap.

Engineering as a profession is seen as reinforcing traditional gender norms, often valuing characteristics such as competitiveness, assertiveness, and objectivity—qualities that align with traditional masculine values (Bahnsen et al., 2024; Ekakoro, 2023). These norms create a culture where women are perceived as less capable or suited for engineering roles, reinforcing stereotypes and bias. Women in engineering may face systemic barriers such as gender discrimination and implicit bias, which can make them feel like outsiders or question their abilities, contributing to a sense of not belonging in the field (Gan et al., 2021).

The readiness of students to engage in engineering education plays a vital role in shaping their potential careers as engineers (Radhakrishnan et al., 2023). For female students, this readiness is even more significant as they often navigate gendered expectations and environments that are predominantly male. Factors such as teamwork, learning environments, and classroom engagement affect the satisfaction levels of female students who pursue engineering degrees. According to Master and Meltzoff (2020), female students' sense of belonging and long-term commitment to the engineering profession can be directly influenced by their overall experience in engineering programmes, especially those with a high male student population.

In fact, student satisfaction with learning experiences has both short-term and long-term effects on their decision to continue pursuing engineering as a major and, ultimately, as a career (Batista-Toledo & Gavilan, 2023; Indira, 2022). The satisfaction gained from learning experiences influences a student's decision to persist in their chosen field of study (Jonaidi & Nasser, 2022; Lucietto & Akdere, 2020), which applies to engineering students as well (Master & Meltzoff, 2020). Dos Santos (2022) expanded on this by stating that the learning experiences of female students significantly affect their retention within engineering programmes and, later, within engineering professions. Thus, satisfaction with the learning experience is crucial in determining whether female students remain committed to engineering over time (Slattery et al., 2023).

Cultural and social factors also play a significant role in shaping students' interest and motivation to study and work in engineering-related fields (Kazembe, 2020). Sociocultural elements such as ethnicity, socioeconomic status, gender career norms, and family background are key influencers in the educational and career choices of female engineering students. These sociocultural influences help to shape the perspectives and motivations of women as they consider entering and progressing within the engineering field. In Malaysia, where cultural norms may encourage or discourage women from pursuing certain career paths, these factors become even more critical to understanding the underrepresentation of women in engineering.

At the heart of these influences lies the concept of identity. Identity is a powerful motivator that shapes individual actions and decisions, including the choice of a field of study (Hansson et al., 2022). Research has shown that identity and learning are interconnected as individuals who can identify with a certain role or field are more likely to persist in it (Ju & Zhu, 2023). Gray et al. (2021) noted that individuals who have a clear understanding of their personal identity are better able to influence their learning outcomes and mastery of a given subject. Chen et al. (2021) further asserted that identifying one's role or identity significantly impacts motivation to engage deeply with a field of study. This applies to engineering, where students who develop a strong engineering identity are more likely to thrive in the profession.

Problem Statements

Engineering is widely regarded as one of the most crucial fields for human development with the potential to add value to products, processes, and services that contribute significantly to economic growth and the enhancement of quality of life. In the 21st century, the rapid expansion of the engineering sector has become evident with increasing demands for skilled professionals to meet the needs of modern economies (Kochetkova, 2021). Despite this growth and the critical role that engineering plays in driving innovation and progress, the participation of women in the engineering profession remains disproportionately low (Hersh & Doyle-Kent, 2023), particularly in civil engineering.

The issue is exacerbated by the competitive nature of HEIs in Malaysia, which are constantly vying for a larger and more qualified student base. The growing number of female students enrolling in HEIs, as stated by the Board of Engineers Malaysia Report (2020), indicates that women are increasingly meeting the high entry requirements, often based on grades, to gain admission to these programmes. However, the limited number of slots for engineering programmes, which are also competitive, may contribute to a selection bias where more women are entering civil engineering programmes based on academic performance rather than genuine interest or passion for the field (Bosen et al., 2023; McIntyre et al., 2024). Bahnsen et al. (2021) noted that while the number of female engineering graduates continues to rise, this has not led to an equivalent increase in their employment within the field. This situation points to a potential waste of resources as the quotas for engineering programmes, which could have been filled by male students more inclined to pursue long-term careers in the field, are occupied by female

students who may not have the same level of commitment to the profession (Gan et al., 2021; Rokoei, 2023). This trend has far-reaching implications for workforce planning and the efficient utilisation of talent within the engineering sector.

The challenges faced by female engineers in pursuing and sustaining a career in civil engineering are complex and multifaceted. Factors such as societal perceptions, family responsibilities, and the less attractive aspects of engineering jobs contribute to the decision of many women to leave the profession or avoid it altogether (Maji, 2019). These challenges underscore the need for institutions to intervene by introducing strategies that address the psychosocial barriers female students may face. The identification of an "engineering identity" for female students can be instrumental in understanding the root causes of this gender disparity and offering tailored support (Gan et al., 2021; Islam & Jirattikorn, 2024).

Engineering identity, as a concept, can help institutions identify female students who may require additional psychosocial support, such as counselling services or mentorship programmes. These initiatives can help students overcome the unique challenges they face in an industry that is still predominantly male (Falco & Summers, 2019; Gearns et al., 2024). By understanding the specific identity and aspirations of female engineering students, HEIs can better align their educational programmes with the interests and needs of their students, ensuring that female graduates are well-prepared and motivated to pursue careers in civil engineering. Therefore, HEIs can implement more effective screening and admission processes to ensure that students, particularly female students, are genuinely interested in and suited for the demands of the civil engineering profession. This will help reduce the wastage of talent and resources by admitting students who are more likely to commit to long-term careers in the field. By identifying and nurturing the engineering identity of female students, HEIs can play a pivotal role in fostering greater inclusion and retention of women in the engineering workforce, ultimately contributing to the advancement of the profession and the economy as a whole.

LITERATURE REVIEW

Engineering Identity

Engineering identity has been increasingly recognised as a crucial determinant of both educational persistence and professional success within the field of engineering. This concept, which focuses on how students perceive themselves as engineers, has been examined in numerous quantitative and qualitative studies. Engineering identity encompasses whether students view themselves as engineers based on the qualities they believe are necessary to fulfil the role of an engineer. These qualities include technical competence, the ability to solve engineering-related problems, and the sense of belonging in the engineering community. Engineering identity is not only shaped by academic experiences but also by social interactions, recognition from peers and mentors, and self-efficacy.

Theories of Engineering Identity

Engineering identity can be measured through a combination of three constructs as proposed by Godwin et al. (2013): (a) belief in performance or competence (i.e., students' confidence in their ability to perform well and understand concepts), (b) interest in the subject, and (c) recognition (i.e., being seen by peers, parents, and teachers as someone capable of performing well in a particular subject). These three factors form the foundation of identity in engineering and are consistent with theories from psychology, sociology, science education, and engineering education.

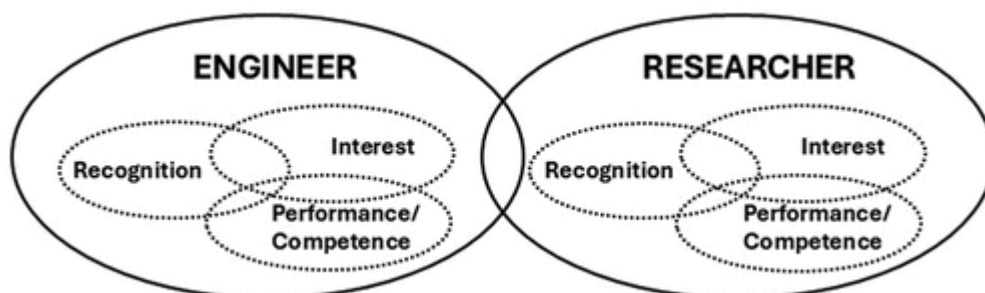


Figure 1 Model of Engineer Identity
Source: Hazari et al., (2012)

According to Godwin et al. (2013), these constructs are critical in capturing how students develop a sense of

belonging and capability within the field of engineering. By measuring student interest in engineering, their perception of being recognised by others as competent in the subject, and their belief in their ability to perform well, educators and researchers can gain insight into how engineering identity is formed (Verdín, 2021). Centered on the Godwin/Hazari identity model—Interest, Recognition, and Performance/Competence (IRP)—this study positions Holland's typology as an environmental framework. Specifically, RIASEC (R-I-C focus) acts as a source of learning experiences that activate the IRP components (Hazari et al., 2012; Godwin et al., 2013).

Holland's Career Typology Theory (RIASEC) and Its Relation to Engineering Identity

John L. Holland's career typology theory (1997) is one of the dominant theories in understanding individual career tendencies based on personality and interests. This theory divides career personalities into six main types: Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C) — collectively known as RIASEC. Each individual will exhibit tendencies towards one or more of these dimensions, which can then be adapted to the corresponding career environment. In the context of higher education and the development of students' professional identity, Holland's theory is often used to:

- i. Explain the suitability of interests with the choice of field of study (Nauta, 2020),
- ii. Predict engagement and commitment to career paths (Tracey & Robbins, 2016), and
- iii. Measure students' adaptation to academic and industrial environments (Smart et al., 2020).

Selection of R-I-C Dimensions for Engineering Field

Based on a literature review and the needs of the engineering field, only three typologies in Holland's theory were identified as most relevant to shaping engineering identities, especially among women in higher education institutions:

- i. Realistic (R):

This dimension refers to an individual's inclination towards physical, technical activities, and the use of equipment or machines. In engineering, students need to interact with materials, technology, and product production processes, which requires interest and ability in practical and task-oriented work.

- ii. Investigative (I):

This element involves logical, analytical, and problem-solving thinking. The ability to research, make scientific inferences, and understand engineering principles makes the Investigative dimension the backbone of student competency development in this field.

- iii. Conventional (C):

Engineering also requires skills in planning, organizing, and adhering to standards or procedures. This dimension is important to ensure that students can function in a systematic organizational structure and adhere to safety and quality guidelines.

Although engineering identity theories such as Hazari et al. (2012) focus on components such as recognition, interest, and competence, an integrative approach through RIASEC allows researchers to identify career personality patterns that are in line with the demands of the engineering field. The selection of only three dominant dimensions (R, I, and C) in this study is based on:

- i. Relevance to actual activities in the engineering field,
- ii. The wide acceptance of these dimensions in the STEM and gender literature, and
- iii. The constraints of selecting female subjects in engineering who commonly show a RIC profile compared to A, S, or E.

Therefore, Holland's theory in the form focused on the Realistic-Investigative-Conventional typology is a solid foundation in building a holistic, practical, and empirical framework for female engineering identity.

METHODOLOGY

A qualitative research design was adopted to examine the engineering identity elements across engineering students. Protocol questions were constructed first before the interviews were conducted. This set of questions has seven semi-structured questions and has been validated in advance by three experts in engineering fields. Once confirmation of the interview request is obtained, an appointment for the interview is initiated.

First, a seven-expert panel with an industry background and engineering academics were gathered. Second, a semi-structured interview was used because the approach entailed a combination of open-ended, closed, and follow-up questions. Specifically, as opposed to relying heavily on verbatim questions such as a structured survey, the interviews revolved around the agenda items and addressed incidental, unexpected issues. Third, the interviews centred on the perspectives from the industry and engineering academics concerning engineering identity among students. Two reasons motivated the selection of industry experts: (a) industry-specific engineering identities

among students could be formulated and (b) once students graduated, these identities could be decontextualised to reflect broader employability skills within engineering fields. During the interviews, follow-up questions were improvised to explore these themes further (Subri *et al.*, 2020). Finally, the interviews were conducted virtually due to travel restrictions.

After the interviews with the seven experts were completed, the recordings of the interviews were converted to a transcript in the form of a document. The document was handed back to the seven experts for them to review the interview results and confirm the transcript. Subsequently, a thematic analysis was employed to identify related narratives. The recurring patterns or themes were coded and identified. The thematic analysis is typically defined as the technique for finding, analysing, and reporting themes (Braun & Clarke, 2006). Thus, to identify constructs of engineering identity was to operationalise a thematic analysis. Four steps governed the processes of thematic analysis. First, before identifying the themes, interview transcripts were grouped and coded. Second, incremental matching across data items and codes was used to compare codes and accuracy search. Third, the codes were reviewed to generate a thematic 'map' of the analysis. Finally, an investigation was carried out to cross-check the details of themes, meanings, and stories.

FINDINGS AND DISCUSSION

The summary and discussion of the main findings are presented in this section. First, the general theme of engineering identity emerged from the interviews among engineering academics and industry experts. As such, the emerging themes were captured as a result of the interviews. Generally, the interviewees were delighted to elaborate on how engineering identity could help students elevate graduate employability. Three important attributes concerning the engineering identity construct were generated from the thematic analysis. Table 1 lists the attributes:

Table 1 Attributes of Engineering Identity

No.	Attributes
1.	Realistic
2.	Investigative
3.	Conventional

However, HEIs might better consider using and applying additional or alternative attributes based on the changes in the industry. Specifically, following the rapid industrial changes, needs, and new skills, additional engineering identity attributes were needed to better align graduates with evolving professional expectations and demands.

Interviews with industry and academic experts indicated that the Holland (RIASEC) typology—specifically the Realistic, Investigative, and Conventional dimensions—remain most relevant as a framework for task environments in engineering education. In line with the Godwin/Hazari identity model (Interest–Recognition–Performance/Competence), the expert panel proposed operationalizing R-I-C into five resulting attributes that are more appropriate for the context of female students and pre-entry screening: (1) Hands-On Technical Orientation (enhancing mastery experiences R), (2) Analytical & Evidence-Based Reasoning (activating evidence-based competencies, I), (3) Standards, Codes & Documentation Discipline (professional accountability, C), (4) Engineer Self-Concept & Recognition Exchange (linking IRP through proximal recognition), and (5) Societal & Sustainable Impact Orientation (linking I↔C to purpose/sustainability). These five attributes do not replace RIASEC but elaborate on it as operational constructs for exploring and assessing female engineering candidate identities.

The new attributes proposed with the new terms by the experts are demonstrated in Table 2:

Table 2 New Attributes of Engineering Identity

No.	Attributes
1.	Hands-On Technical Orientation
2.	Analytical & Evidence-Based Reasoning
3.	Standards, Codes & Documentation Discipline
4.	Engineer Self-Concept & Recognition Exchange
5.	Societal & Sustainable Impact Orientation

Based on the findings, it could be concluded that the eight engineering identities were relevant for graduate development and employability, helping to shape their professional identity and align them with industry expectations. Developing a strong engineering identity is particularly important as they navigate gendered

environments and cultural expectations that may not traditionally associate women with technical professions. Research shows that the formation of an engineering identity can be a critical predictor of persistence in both educational and professional contexts, particularly in male-dominated fields such as civil engineering (Gray et al., 2021). This section explores the literature on the key elements that contribute to the development of engineering identity in female students, which are essential for understanding their career decisions in higher education.

i. Hands-On Technical Orientation (R)

Practical orientation refers to a candidate's tendency to "learn by doing" through exploration of equipment, laboratory experiments, and basic safety procedures. For female students in the pre-entry phase—who may come from a general stream—this dimension signifies a willingness to move from descriptive knowledge to concrete technical practice. The literature shows that authentic experiences (e.g., demonstrations, guided lab modules, or simple design activities) strengthen engineering identity because they build conceptual understanding, self-efficacy, and a sense of "I can do" in the technical workspace (Godwin et al., 2016; Gray et al., 2021). Meaningful early exposure, even on a small scale (a video of a manufacturing process, a basic experimental kit, or a virtual tour of a facility), can spark ongoing interest and connect scientific concepts to real-world applications (Lucietto & Akdere, 2020; Ju & Zhu, 2023). Multi-stakeholder programs such as TRUE or summer bridges have also been found to support the transition from interest to identity through structured training and mentoring (Radhakrishnan et al., 2023; Smith & Williamson, 2024). For female candidates, this R element is important to overcome stereotypical expectations of "tool/machine work" and normalize the comfort of being in often male-dominated labs/workshops—thereby strengthening intentions to pursue engineering studies and careers.

ii. Analytical & Evidence-Based Reasoning (I)

The analytical dimension encompasses the willingness to think systematically, test hypotheses, use data/evidence, and connect mathematical and physical principles to real-world problems. In an identity framework, this construct channels "competence beliefs" into intentions to pursue a field, particularly when female candidates see themselves as able to structure problems and support decisions based on evidence (Godwin et al., 2013; Way et al., 2020). Studies have shown that data-based tasks—for example, processing small data sets, sketching simple models, or making numerical justifications—cultivate sustained interest and shift the focus from "right/wrong" to evidentiary reasoning (Indira, 2022; Jonaidi & Nasser, 2022). Cognitive apprenticeship and reflective practice also help students develop repeatable problem-solving strategies (Jensen et al., 2023). For female candidates, success on early analytical tasks increases a sense of competence, reduces self-doubt, and supports the formation of a strong engineering identity despite the lack of formal project experience. When combined with explicit feedback, dimension I becomes a strong predictor of academic persistence and career intentions in engineering programs.

iii. Standards, Codes & Documentation Discipline (C)

The "Conventional" dimension in RIASEC is often misunderstood as purely administrative, whereas in engineering it is the core of professionalism: compliance with standards/codes, thorough documentation, traceability of results, and a culture of quality and safety. For female candidates, the emphasis on structure, SOPs, and systematic records reinforces the role identity of the "trusted engineer" who makes auditable decisions, in line with public and stakeholder needs (Smart et al., 2020; Keku et al., 2021). Standards literacy from the beginning connects ethics, risk, and sustainability—thus transforming "rules" into technical rationales that protect users and the environment (Oldham et al., 1976; Godwin et al., 2016). Micro-practices such as the use of checklists, version naming, result logging, and code referencing (e.g. Eurocode/BS/MS) form professional habits that increase candidates' self-confidence to participate in a work culture that demands rigor. This is important in a gender context, as C competencies help to counter stereotypical perceptions of women's technical abilities with transparent and consistent evidence of work. In short, C bridges analytical competence to professional accountability—an important marker of readiness to enter engineering programs and subsequently careers.

iv. Engineer Self-Concept & Recognition Exchange (Identity Core)

This attribute combines "seeing oneself as an engineer" (self-concept) with "being recognized as competent" (recognition) by teachers, peers, and family—two elements that, according to the Hazari/Godwin identity model, drive persistence in the field (Hazari et al., 2012; Godwin et al., 2013). For female students, proximal recognition (lecturer/friend/family) is more influential than distal sources (industry professionals) in the early stages, especially in male-dominated environments (McIntyre et al., 2024; Wilson & VanAntwerp, 2021). Studies show that high interest without recognition is often insufficient to maintain identity; clear feedback, opportunities to present ideas, and the definition of a meaningful role in a group increase the sense of "I belong here" (Kalender et al., 2019; Rodriguez et al., 2019). Interventions that normalize female students' technical voices—for example, transparent presentation rubrics, facilitation turns, and formative comments—can reduce self-doubt and role stereotyping. Practically for pre-admission screening, these indicators help identify candidates who already have a positive identity narrative (even without project experience), thus predicting their willingness to take on academic challenges and survive to the professional level.

v. Societal & Sustainable Impact Orientation (I↔C)

Many studies show that female students are more likely to maintain interest when they see a fit between personal goals and the social role of engineering—for example, safety, community welfare, and sustainability (Diekman et al., 2010; Keku et al., 2021). This orientation is not “extra-technical”; it ties analytical reasoning (I) with compliance with standards (C) to produce safe, ethical, and sustainable decisions. Curriculum experiences that emphasize impact (clean water projects, safe transportation, renewable energy) increase a sense of relevance, motivation, and a sense of belonging to a professional community (Shortlidge et al., 2024; Chandra et al., 2024). Psychologically, when female candidates see engineering as contributing to global problems, their role identity is strengthened—thus dispelling narrow masculine stereotypes (Saigo, 2024). In the pre-entry phase, testing for propensity to weigh safety, ethics, and end-user aspects helps assess candidates’ value-technical readiness. Impact literacy also supports communication with stakeholders—an increasingly critical competency in the modern engineering profession.

CONCLUSION

Overall, the synthesis between the Godwin/Hazari identity framework and the Holland typology (RIASEC) provides a strong theoretical foundation for understanding and assessing engineering career choices among female students. The Godwin/Hazari model describes the psychosocial mechanism of Interest–Recognition–Performance/Competence (IRP) that predicts academic and professional persistence (Hazari et al., 2012; Godwin et al., 2013; Bahnsen et al., 2021), while RIASEC—specifically R-I-C—provides the context of learning experiences (hands-on, evidence-based reasoning, and standards compliance) that activate these IRP components (Smart et al., 2020; Ju & Zhu, 2023). Based on these two frameworks, expert interview findings refined the R-I-C into five resulting attributes that could be operationalized for pre-admission screening: (1) hands-on technical orientation, (2) analytical and evidence-based reasoning, (3) standards, codes and documentation discipline, (4) engineer self-concept and recognition exchange, and (5) societal and sustainable impact orientation.

These five attributes link engineering task orientation to identity formation that is relevant for female students, especially in male-dominated environments (Young et al., 2024; Schell et al., 2022). The R and I attributes build early mastery and efficacy experiences without requiring a track record of previous projects (Gray et al., 2021; Radhakrishnan et al., 2023), the C attribute emphasizes professional accountability that is easily assessed and recognized (Keku et al., 2021), the Self-Concept/Recognition attribute reinforces a sense of “inclusion” through proximal recognition (McIntyre et al., 2024), while the Social Impact attribute integrates values and purposes known to drive women’s motivation to remain in the field (Diekman et al., 2010; Shortlidge et al., 2024). Thus, HEIs can use these five attributes as the basis for an initial screening instrument that is fair, gender-sensitive without bias, and aligned with program needs—to screen for genuine interest, willingness to learn, and potential for persistence—thus reducing waste of resources and increasing career sustainability of women engineers.

Implications for Higher Education Institutions (HEIs)

The study’s findings have important implications for HEIs and the broader engineering community. To support the development of a strong engineering identity among female students, institutions need to create more inclusive environments that recognise and validate the contributions of female students. This can be achieved through mentorship programmes, faculty support, and peer networks that provide encouragement and recognition for female students’ skills and achievements.

Institutions should also emphasise the societal relevance of engineering in their curricula, aligning learning experiences with the values and motivations of female students who are often driven by the desire to make a positive impact on society. Providing opportunities for female students to engage in real-world engineering projects that address social and environmental challenges can help sustain their interest in the field and reinforce their engineering identity.

Furthermore, institutions should offer practical experiences, such as internships and cooperative programmes, to allow female students to gain hands-on experience and build confidence in their technical abilities. Early exposure to engineering through outreach programmes targeting young girls can also play a crucial role in shaping interest and identity in the field.

Finally, institutions must address the issue of gender norms and stereotypes by actively promoting gender diversity and creating a culture of inclusivity within engineering programmes. By challenging societal perceptions of engineering as a male-dominated field and providing female students with the support they need to succeed, institutions can help foster a stronger engineering identity among female students and encourage more women to pursue long-term careers in civil engineering.

RECOMMENDATION

Drawing on the synthesis of the Godwin/Hazari (IRP) framework and the RIASEC context (R-I-C focus) and the resulting five attributes, HEIs should implement identity-based pre-admission screening that is diagnostic, not exclusive. Develop a simple instrument that operationalizes the five attributes—Hands-On Technical Orientation, Analytical & Evidence-Based Reasoning, Standards/Codes & Documentation Discipline, Engineer Self-Concept & Recognition Exchange, and Societal & Sustainable Impact Orientation—to identify genuine interest, readiness to learn, and support needs. Ensure psychometric quality (reliability $\geq .70$, content validity, and basic measurement invariance), clear data governance, and automated referral pathways to appropriate interventions (mentors, bridging modules).

Next, institutionalize structured mentoring and proximal recognition. Pair new students with faculty/industry mentors and peer mentors; practice transparent feedback through “studio crits,” assessment rubrics, and performance showcase sessions. Strengthen the visibility of female role models/alumni, practice bias-aware assessment, and offer scholarships and ambassador programs to normalize women’s participation in civil engineering.

Align curriculum and early experiences with R-I-C: 2–4 week pre-semester modules that include safety & makerspace workshops (R), data-based mini-assignments and numerical justifications (I), and documentation/SOP training and short audits (C). Integrate social impact/sustainability micro-projects so that purpose-based motivation supports identity formation; expand access to industrial training/micro-internships with industry partners that emphasize standards, safety, and public impact.

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