Key Dimensions and Impact Factors on STEM Identity Among Female Students: A Systematic Literature Review

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ABSTRACT

Facing a gender gap in Science, Technology, Engineering, and Mathematics (STEM) fields, various ongoing efforts have been made to promote gender equality in STEM education. However, female students continue to be underrepresented in academic fields and STEM-related careers, both nationally and globally. This study addresses the issue of persistent gender imbalance by identifying the key dimensions and factors influencing STEM identity among female students. Utilizing the systematic literature review (SLR) approach, 51 empirical studies published between 2016 and 2025 were identified through databases such as Web of Science (WoS) and Scopus. Data were extracted and analyzed through a thematic method guided by Carlone and Johnson's identity framework, which encompasses interest in STEM, competence and achievement, recognition by others, and a sense of belonging. The findings indicate that the formation of STEM identity among female students is influenced by complex interactions between individual characteristics (such as self-efficacy and motivation), interpersonal relationships (such as family, teachers, and peers), institutional structures (such as inclusive pedagogy and access to mentors), and broader societal influences (such as stereotypes and cultural expectations). These dimensions reinforce each other, and imbalances between them—for example, high levels of competence without recognition—can weaken the formation of identity. The study highlights the need for multi-level interventions that target student engagement, teacher training, inclusive school environments, and a national framework addressing systemic gender bias. Identification of female students' constructs and ways to navigate their STEM identities can help stakeholders, including educators, policymakers, and the STEM industry, create a more equitable and supportive ecosystem to encourage long-term participation of women in STEM fields.

Keywords: STEM identity, female students, systematic literature review

INTRODUCTION

Transformation in education is occurring rapidly and has become a norm in navigating the modern world. Among the changes that have often received attention are the interdisciplinary fields of science, technology, engineering, and mathematics (STEM). The term STEM has become commonplace in the educational system today. The integration of the four core subjects into the STEM acronym is a pragmatic decision by experts in these fields, with the hope of demonstrating the effectiveness of integrating the disciplines in solving problems in this challenging ecosphere (Falloon et al., 2021). The implementation of STEM education has received significant attention and has become a key focus in education, politics, and the economy at the global level (Muda et al., 2023). According to the *Science for All Americans* report (1991), STEM education should equip students with the knowledge and ability to adapt to social life by participating in discussions, making decisions, and solving everyday problems (Augusto et al., 2022).

In this era of innovation, character building in students is crucial and has become a primary driver of human capital success. Self-perception becomes the primary motivator and stimulant for their confidence in achieving goals in STEM fields. Through STEM identity, this can be achieved successfully (Lockhart et al., 2022) because students feel more confident venturing into STEM fields when they have a positive self-perception. If they find an activity interesting and satisfying, the experience can reinforce their STEM identity, generating positive feedback loops that can further increase engagement and continuous learning.

Conversely, when students experience uninteresting or unsuccessful experiences, a negative feedback loop may

occur, which can lead to a decline in their developing STEM identity and make them less likely to pursue STEM fields in the future. According to Dou and Cian (2021), this STEM identity is formed and reshaped through continuous engagement with STEM activities, feedback from peers and mentors, and broader cultural norms and structures within STEM fields.

LITERATURE REVIEW

STEM identity is a crucial indicator of an individual's ability to achieve their dream career and their success in today's educational environment (Singer et al., 2020). This is because through STEM identity, students will feel *a sense of belonging* in the STEM field. This is crucial for enhancing students' motivation and fostering positive attitudes. Understanding and strengthening STEM identity among students is important because it influences continued participation, learning, and potential career paths in STEM disciplines. In addition, STEM identity is not merely about possessing knowledge or skills in STEM, but also about seeing oneself as someone capable, who can contribute, and who is recognized within the STEM community. It encompasses questions about self-perception, such as "Who am I in the context of STEM?", "How do I relate to STEM disciplines?", and "How do others see my relationship with STEM?" (Bell et al., 2018).

The issue of female students' participation in the STEM field, particularly at the secondary and higher education levels, has been an enduring concern, with female students' participation remaining low compared to that of male students (Yaşar Kazu & Yalçin, 2021). This situation raises concerns about gender imbalance in STEM-related careers, which could potentially impact national human resource development. This is due to several extrinsic and intrinsic factors within female students themselves that make them more inclined to choose fields other than STEM as a career option or for continuing their education. According to the United Nations Report 2022, women make up only 35% of students in STEM fields (Rachel, 2023), despite an increase in women's digital competencies, such as basic information and communication technology (ICT) skills.

Additionally, female students are not interested in engineering as a field of study because they find the curriculum too complex and the workload excessive (Susana et al., 2022). This is closely related to the formation of the STEM identity, which involves a sense of belonging, competence, and knowledge in STEM fields, as well as interest and social recognition from the surrounding community.

The STEM identity model, introduced by Carlone and Johnson (2007), encompasses three important components: competence or knowledge, achievement, and recognition/sense of belonging. Studies by Hazari et al. (2020) and Craig (2022) state that STEM identity, which refers to an individual's sense of belonging, competence, and self-recognition in the STEM field, encompasses various personal, social, and contextual factors. As emphasized by Hazari and Craig, STEM identity consists of cognitive, affective, and behavioral components, reflecting not only mastery in STEM subjects but also emotional involvement and behavioral tendencies toward activities and careers related to STEM fields. Several factors contribute to the formation and development of STEM identity in students, particularly among female students.

Various studies (e.g., Estelle et al., 2024; Queshonda & Michael, 2025; Hui-Hui & Neil, 2022) have been conducted to examine female students' participation in STEM fields; however, their STEM identity remains unclear and incomplete. Previous studies have indicated that various factors, including teacher support, peer influence, perceptions of self-efficacy, and meaningful learning experiences, influence the formation of female students' STEM identities (Estelle et al., 2024; Queshonda & Michael, 2025; Hui-Hui & Neil, 2022). The results of these studies are often fragmented, contextual, and not systematically synthesized. Thus, the purpose of this study is to scientifically examine and analyze the characteristics of female students' STEM identity through a systematic literature review (SLR) of findings from past studies and empirical data. This is important because it can address the increasingly alarming gender gap in STEM at the global level. Today, the STEM sector is no longer considered a male-dominated field; instead, women are increasingly venturing into STEM fields due to the demands and changes brought about by modernization, which require a skilled STEM workforce, regardless of gender.

Additionally, the SLR can also be used to identify gaps in existing studies on the formation of STEM identity among female students. For example, numerous studies have been conducted in developed countries, such as the

United States (Peter et al., 2025; Pigot & Polanin, 2020), as well as England, Scotland, Wales, and Northern Ireland (Estelle et al., 2024). Therefore, researchers can not only identify empirical data and existing knowledge but also identify gaps that have yet to be explored, leading to more meaningful and contextual contributions in efforts to enhance the participation of female students in STEM fields. Moreover, SLR on the characteristics of female students' STEM identity based on the main dimensions of identity has not been conducted, prompting researchers to focus on this new study to identify recurring patterns, theoretical trends, methodologies used, and key conclusions presented by previous studies. It is essential to identify similarities and differences in findings, as well as to determine how specific characteristics or factors are related to the STEM identity of female students across diverse cultural, social, and educational contexts.

For this study, the following research questions were addressed: (1) What are the characteristics of female students' STEM identity based on four dimensions, namely interest in STEM, achievement and competence, social recognition, and sense of belonging? (2) What factors influence female students' STEM identity based on macro society, the education system, the school community, the role of the family, and the students as individuals?

METHODOLOGY

Inclusion Criteria

Only research articles focusing on STEM identity among female students, written in English and published in peer-reviewed journals between 2016 and 2025, were selected for this study. To ensure the quality and reliability of the study findings, we excluded conference proceedings, reports, bibliographies, theses, and other forms of "gray literature" as they are generally considered to have a lower level of academic rigor (Kyeremeh et al., 2023). Additionally, article selection was limited to publications indexed in two high-impact academic databases: Web of Science (WoS) and Scopus.

Data Analysis Procedure

A within-case analysis (Miles & Huberman, 1994) was first conducted on 51 empirical studies, with each article serving as a unit of analysis. The studies were classified across nine dimensions: interest in STEM, competence and achievement, social recognition, sense of belonging, macro-societal factors, the education system, the school community, the home context, and the individual student. Dimensions one to four addressed Research Question 1, while dimensions five to nine informed Research Question 2.

Subsequently, a cross-case analysis (Miles & Huberman, 1994) was conducted, with the two research questions and nine dimensions serving as the units of analysis. This process systematically compared and synthesized findings across studies to capture both convergences and divergences, thereby providing an integrated account of STEM identity formation among female students and the factors influencing it.

A systematic literature review (SLR) is a structured and transparent method for synthesizing empirical evidence from prior studies, thereby minimizing bias, ensuring replicability, and providing a robust foundation for future research (Anuar et al., 2023). This review adopted such an approach to examine the dimensions of STEM identity among female students and the factors influencing it.

To ensure validity and reliability, systematic procedures were followed in data extraction, coding, and synthesis. Face validity was established through supervisory feedback to confirm alignment between the constructs and research objectives. In contrast, content validity was strengthened by expert input, which refined the conceptual boundaries of STEM identity and its influencing factors. All feedback was incorporated into the analytical framework to ensure that the review captured the multidimensional nature of the construct.

Further strategies were applied to strengthen trustworthiness. An audit trail documented all stages of the review process, enhancing transparency. Peer debriefing with colleagues and supervisors allowed critical reflection and reduced researcher bias. Triangulation of findings across multiple studies minimized selective reporting and strengthened the credibility of the synthesis.

Through these measures, the review systematically organized and synthesized prior findings, generating both descriptive mapping and analytical insights into STEM identity development among female students.

Literature Search and Assessment

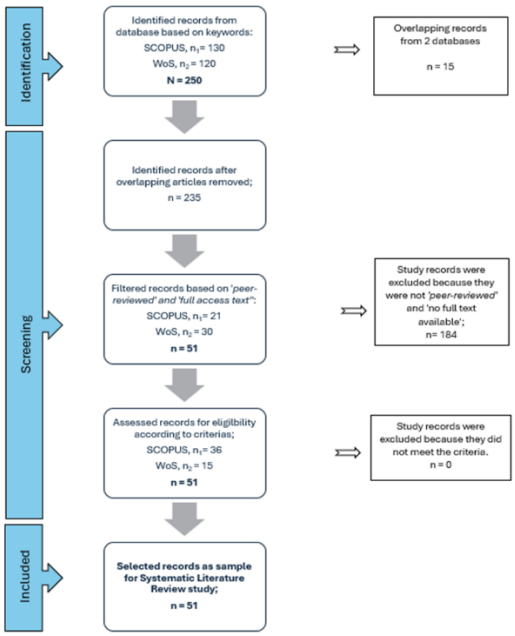
This study focuses on STEM education, particularly for female students. A systematic literature review was conducted thoroughly on STEM and mathematics identity in the context of female students by synthesizing and analyzing empirical data obtained from selected studies. All selected studies met the established criteria and were analyzed not only based on abstracts, but also through a complete reading of the studies related to STEM identity among female students. The researcher conducted three screening steps to analyze empirical studies and select those relevant to the study's issues and questions.

First, based on the researcher's search using the Boolean search method and the keywords TITLE-ABS-KEY (("STEM identity") AND (girl* OR female* OR woman OR women OR gender)) AND PUBYEAR > 2015 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA, "SOCI")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (OA, "all")), the researcher found approximately 250 articles from two high-impact databases, namely 130 articles from SCOPUS and 120 articles from WoS.

Next, all duplicate articles will be removed to ensure no duplicate data in the final study results. Based on the reviewer's observations, 15 articles overlapped in both databases, SCOPUS and WoS. Then, the criteria and limitations of the study were further refined to ensure that all selected studies met the reviewer's primary requirements, namely that all studies were peer-reviewed and only articles with full-text access were selected. As a result of the refinement, the researcher identified 51 articles that passed the screening, with 21 articles from SCOPUS and 30 articles from WoS. The results of this screening showed a significant reduction, with more than half of the articles lacking full-text access and not being *peer-reviewed.*

Finally, an in-depth review of all articles that passed the screening was conducted to identify those relevant to the objectives and research questions of the reviewers regarding STEM identity among female students. Based on several final criteria, all selected studies must be in Malay or English; articles not in Malay or English were excluded. The articles must have been published within the last 10 years, from 2015 to 2025. All articles published before 2015 were excluded to maintain the quality and validity of the research findings. The researcher selected only journal articles and excluded conference proceedings, conference papers, and book reviews. Furthermore, to complete the research and selection of articles, they must be related to the field of social sciences only. Therefore, the researcher has selected a total of 51 articles, with 21 articles from SCOPUS and 30 articles from WoS. The details of the article selection process as a sample for this SLR study are shown in **Figure 1.**

Figure 1 Flowchart of the studies' selection process

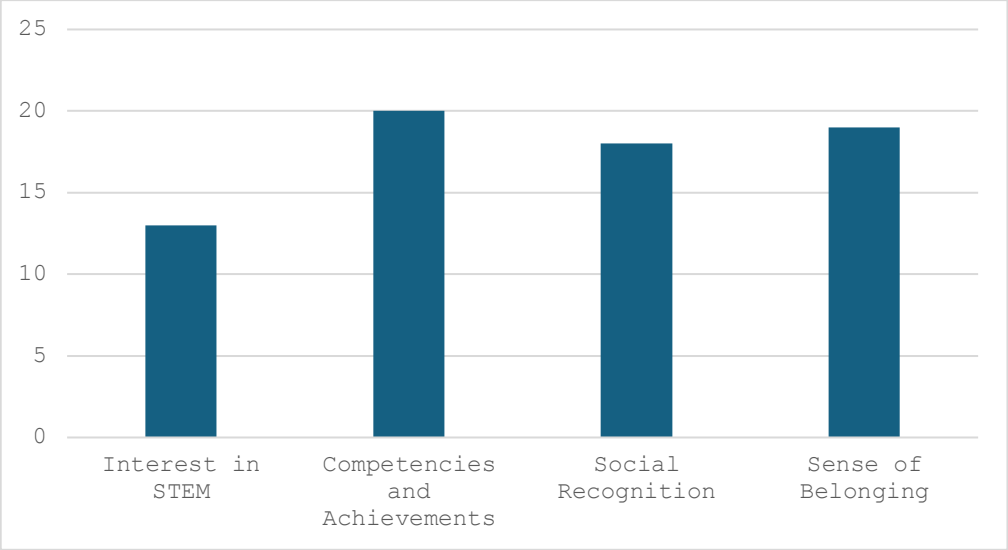


FINDINGS

STEM Identity

In this study, 51 articles (Figure 2) were systematically analyzed to identify the characteristics of female students' STEM identity based on four main dimensions of identity: interest in STEM, competence and achievement, social recognition, and sense of belonging. For the first dimension, interest in STEM, it was found that 13 of the 51 analyzed articles described and provided findings on the characteristics of interest in STEM as the primary indicator of female students' STEM identity. It is worth noting that several articles also reported findings with more than one dimension (Rillero et al., 2025; Tofel-Grehl et al., 2024; Calkins et al., 2023; Dou et al., 2021). Both competence and achievement are the most frequently identified dimensions of STEM identity, as noted in the 51 selected articles, with 20 articles addressing each dimension.

Figure 2 Number of articles based on the four main dimensions of female students' STEM identity



Interest in STEM

Interest in STEM is one of the most consistent elements identified as an early driver of STEM identity formation among female students. In this context, interest is defined as sustained engagement, curiosity, and enjoyment of STEM content and activities, which drives active involvement and long-term aspirations (Eccles & Wigfield, 2020). Through the analysis of 51 scientific articles published between 2019 and 2024, the findings indicate that more than one-third of studies suggest that the contextual and early cultivation of interest is crucial for stimulating a robust STEM identity.

A consistent pattern emerges when interest is shown to be cultivated through learning activities closely linked to students' daily lives and experiences. Rillero et al. (2025) demonstrate how a community-based approach combining gardening activities successfully increased the interest of Latinx girls in STEM. This aligns with the findings of Milton et al. (2023), who found that collaborative and "hands-on" approaches, such as science summer camps, were able to strengthen minority student engagement through culturally sensitive and experience-based approaches. Both studies indicate that interest cultivation must be authentic, contextual, and inclusive. Exposure through media also plays a crucial role in shaping perceptions and initial interest in STEM. Aladé et al. (2022) reported that television programs featuring women as scientists successfully challenged stereotypes and increased girls' interest in STEM careers. This is supported by Phillips et al. (2022), who examined the impact of visual storytelling through Instagram's “Women Doing Science” initiative. This initiative not only increased the visibility of women in STEM but also made the field more inclusive and accessible to all.

Informal learning, such as museum programs, family activities, and science-related conversations at home, also has a significant impact on girls' interest in STEM (Dou et al., 2019; Zhao et al., 2024). In this context, informal experiences provide a space for self-exploration without pressure, while also strengthening the emotional

dimension in the formation of STEM interest and identity. However, studies such as those by Galanti and Holincheck (2025) remind us that interest alone is insufficient without strong social support. Female students interested in mathematics still experience identity conflicts due to gender stereotypes that claim mathematical ability is a masculine trait. This study emphasizes that social recognition from teachers and peers is crucial in stabilizing interest and translating it into a stable STEM identity.

Comparisons of various studies indicate that interest generated by independent projects and inquiry-based learning is more effective than exam-oriented teaching (Singer et al., 2020; Starr et al., 2020). Learning that enables students to build arguments, evaluate data, and contribute to real-world communities not only generates interest but also strengthens their ownership of a STEM identity. Interest in STEM among female students is not formed spontaneously but is influenced by pedagogical stimuli, social support, and inclusive cultural representation. Therefore, interest should be seen not only as an initial indicator but as the basis for fair and inclusive pedagogical interventions. The cultivation of interest must be combined with recognition and systemic support to ensure that female students are not only interested but also see themselves as part of the STEM community.

Competencies and Achievement

Furthermore, competence and achievement are key dimensions in the formation of STEM identity among female students. These dimensions involve self-perceptions of competence in STEM fields and recognition of academic or practical achievements as indicators of performance. In a comparative analysis of 20 selected articles, all studies indicate that perceptions of competence play a crucial role in enhancing the self-confidence and identity awareness of female students who are pursuing STEM careers. For instance, Galanti and Holincheck (2025) emphasize that high academic achievement does not necessarily lead to self-recognition as competent, mainly when gender stereotypes are deeply rooted in societal perceptions. Conversely, Zhao et al. (2024) found that increased science self-efficacy can enhance career aspirations in science, while also strengthening STEM identity. This highlights the importance of self-empowerment as a complement to academic achievement.

Pedagogical approaches are also important factors in building competencies. Rillero et al. (2025) and Edelen et al. (2024) suggest that project-based learning and visual techniques such as photo-elicitation can increase students' ownership of the learning process. This approach not only stimulates student engagement but also reinforces their perception of their ability to solve real-world problems. Milton et al. (2023) and Kuchynka et al. (2023) demonstrate how specialized programs such as STEM camps and female faculty mentoring are effective in strengthening the confidence of female students from minority communities. This is supported by González Peña et al. (2024), who state that authentic learning environments provide students with a realistic opportunity to assess their competencies. In a different context, Mulvey et al. (2023) note that interpersonal skills and motivation also contribute to academic achievement and the reinforcement of STEM identity.

Several studies also explored the role of social media as a platform for competency development. For example, Steinke et al. (2024) demonstrate how young female scientists utilize platforms like TikTok to showcase their skills, thereby inspiring other young female students. In another study by Grimalt-Álvaro et al. (2022) and Ackert et al. (2021), minority students who succeed in STEM associate their achievements with learning experiences that go beyond the formal classroom. Additionally, a study by Colantonio et al. (2021) highlights that confidence in specific subjects, such as astronomy, can influence whether a student identifies as part of the scientific community. However, as demonstrated by Milton, Sager, and Walkington (2023) and Verdín et al. (2018), even when high achievements are attained, social context, such as a lack of representation or unsupportive environments, can still undermine confidence.

Finally, Balasubramanian et al. (2023) and Clark et al. (2016) emphasize the importance of institutional strategies such as leadership programs and psychosocial support in transforming academic achievement into a stable professional identity. Without social validation and institutional recognition, female students' achievements in STEM may not translate into long-term confidence or aspirations. Thus, competence and achievement should not be viewed in isolation but rather understood as the result of interactions between academic performance, authentic learning experiences, and social influences. In shaping the STEM identity of female students, academic success must be accompanied by experiences that reinforce self-efficacy, positive feedback, and a learning

environment free from gender stereotypes. Therefore, comprehensive educational interventions must emphasize the holistic reinforcement of both dimensions to expand women's participation in STEM fields.

Social Recognition

In the STEM education discourse, social recognition emerges as a critical factor in determining whether female students recognize themselves as legitimate members of the STEM community. This concept encompasses validation from various external parties such as teachers, peers, family, media, social communities, and educational institutions regarding students' abilities and active participation in STEM fields (Carlone & Johnson, 2007). The analysis reveals that recognition not only serves as an intrinsic motivator but also as a structural validator for the existence of a STEM identity. For instance, Steinke et al. (2024) demonstrated that social media platforms, such as TikTok and Instagram, serve as influential informal recognition spaces for young women. Visual content is used not only to share scientific achievements but also to convey daily narratives and struggles faced by women in STEM. Recognition through follower support, such as comments and "likes," provides psychological validation to female students and encourages them to see themselves as part of the scientific community.

However, recognition is also influenced by narratives in mainstream culture. Gürkan and Echazarreta-Soler (2023) analyzed the representation of female scientists in films. They found that when women are portrayed as authoritative and complex scientific protagonists, it has a positive impact on public perception and gender expectations. This expands the dimension of recognition to cultural symbolism, demonstrating how mass culture contributes to the legitimacy of women's presence in STEM. A comparison with a study by Phillips et al. (2022) through the Instagram platform "Women Doing Science" proves that visualizing female scientists from diverse backgrounds has a direct impact on STEM identity attainment. Unlike mainstream media, which can sometimes be stereotypical, community social media provides a space for horizontal recognition where female students see scientists who are "like them," making STEM identity more realistic and inclusive.

However, not all forms of recognition lead to the formation of positive identities. Corbett et al. (2024) revealed that in toxic academic contexts—characterized by discrimination, bullying, and a lack of appreciation for women's contributions—many female students and professionals leave STEM fields. This emphasizes that recognition must be genuine and comprehensive, not merely symbolic. In the classroom context, Galanti and Holincheck (2025) found that, although female students achieved excellent grades, the lack of recognition from teachers and peers hindered their development of confidence as STEM professionals. This micro-level recognition plays a crucial role in translating achievements into a stable self-identity. Finally, research by Birney and McNamara (2022) demonstrates that involving female students in community projects, such as ecological restoration, not only enhances their STEM skills but also provides them with direct social recognition from the community. This expands the scope of recognition to a broader social realm, making STEM collectively relevant.

Overall, social recognition is a dimension of structure and emotion that is interrelated in the formation of female students' STEM identity. It occurs in various formal and informal, digital and cultural, micro and macro spaces, and all play the same function: to validate, give meaning, and reinforce the presence of female students in the STEM landscape. Therefore, any strategy to strengthen women's participation in STEM must ensure that recognition is not only present but also of high quality, inclusive, and sustainable.

Sense of Belonging

A sense of belonging is a crucial dimension in the formation and maintenance of female students' STEM identity. This dimension not only fosters emotional attachment to the STEM field but also influences self-confidence, resilience, and motivation for students to remain on the STEM education and career path. Based on a synthesis of 19 selected articles, a sense of belonging has been proven to be a key psychosocial enabler in supporting the continued engagement of female students in scientific communities. In this regard, a study by Birney and McNamara (2022) found that active involvement of female students in community-based environmental restoration projects increased their sense of belonging in STEM communities. This aligns with the findings of Starr et al. (2020), which showed that collaborative learning in scientific practices enhances feelings of being valued within academic groups, thereby strengthening STEM identity. These studies highlight the significance

of meaningful and authentic social interactions in promoting a sense of belonging.

However, toxic learning environments undermine female students' sense of belonging. Corbett et al. (2024) warn that experiences of bullying and harassment in academic institutions can erode a sense of belonging. Tofel-Grehl et al. (2024) also emphasize the need for learning spaces that recognize the identities of LGBTQ+ female students, who can only develop a sense of belonging when they are entirely accepted and acknowledged. These findings are supported by studies by Yeldell et al. (2024) and Fan et al. (2023), which emphasize that minority female students form a sense of belonging when STEM is linked to social justice and community development. In this context, a sense of belonging arises when learning is directly related to students' lives and values. Additionally, Zhao et al. (2024) found that participation in informal programs such as STEM camps enhances self-efficacy and a sense of belonging reciprocally. In these informal settings, female students are free to explore and express their interests, making STEM more personal and accessible.

Support from family and community also plays an important role. Dou et al. (2019) emphasize the importance of science-related conversations at home, which help build affective relationships and support outside the classroom. Godec et al. (2024) introduce the concept of "science capital," which refers to the social and cultural resources that support engagement in science. They found that female students with low science capital can still develop a sense of belonging when their voices are valued in the classroom. Wong and Copsey-Blake (2023) continue this discussion by showing that minority female students are highly dependent on small supportive communities to build a sense of belonging in a dominant educational environment. The role of role models who understand students' backgrounds is also significant, as demonstrated in the studies by Fan et al. (2023) and Campbell-Montalvo et al. (2022), where caring mentors and identity-focused organizations enhance students' presence and persistence in STEM fields. Edelen et al. (2024) also highlight the effectiveness of photo-elicitation as an approach that allows students to voice their experiences in research. Self-representation in this research strengthens their sense of belonging and makes their participation more meaningful. Such strategies are important in reducing the gap between students and the mainstream STEM community.

Overall, all 19 articles support the notion that a sense of belonging is a key enabler of STEM identity formation among female students. It is formed through a combination of social support, cultural participation, opportunities to voice opinions, and legitimate representation in the scientific community. Therefore, a culturally responsive, inclusive, and identity-friendly STEM education ecosystem is essential for fostering and sustaining a sense of belonging.

Factors Influencing the Development of STEM Identity in Female Students

The formation of STEM identity among female students cannot be understood in isolation from the social context that surrounds them. Five key factors—macro society, the education system, the school community, family involvement, and individual students—interact dynamically to shape or hinder the development of this identity. These factors interact with each other, forming a holistic environment that influences students' beliefs about their capabilities, the social legitimacy of pursuing STEM fields, and their ability to remain in STEM-related career paths. Based on a systematic analysis of more than 90 articles, these five factors provide a comprehensive picture of the structure and challenges faced by female students in developing their STEM identity.

Macro-societal factors encompass value systems, social norms, popular culture, and mass media that influence collective imaginations about who is "eligible" to be in STEM fields. An analysis of 19 articles shows that macro-society plays a significant role in reinforcing or challenging gender stereotypes. A study by Gürkan and Echazarreta-Soler (2023) found that cultural narratives in films and mainstream media still prominently feature male scientists as main protagonists, while women are often portrayed as supporting characters or sidekicks. These narratives narrow the aspirations of female students from an early age. However, social media opens up space for more progressive alternative narratives. Studies by Steinke et al. (2024) and Phillips et al. (2022) demonstrate that platforms such as Instagram and TikTok enable young women to visually and publicly showcase their STEM identities, thereby expanding their visibility and social recognition. Campaigns like #WomenInSTEM not only boost confidence but also foster supportive online communities. However, structural factors such as gender discrimination and unequal opportunities still exist. Corbett et al. (2024) emphasize the presence of toxic culture in academia that blocks women's access to professional development opportunities. In

the context of female students from minority backgrounds, as reported by Yeldell et al. (2024), intersectional discrimination based on race and gender increases the risk of their withdrawal from STEM pathways. Therefore, macro-level society must be strengthened through representative frameworks, the promotion of inclusive media, and critical literacy education to challenge gender stereotypes that hinder the progress of female students in STEM fields.

The education system also functions as a formal structure that shapes students' identities through curriculum, pedagogy, and school culture. Of the 26 articles analyzed, it was found that teaching approaches and curriculum content have a direct impact on the formation of female students' identities in STEM fields. Studies by Starr et al. (2020) and Singer et al. (2020) demonstrate that authentic experiential learning enables students to perceive themselves as legitimate experts in STEM fields. Involvement in real-world activities increases students' confidence in their abilities. Furthermore, Tofel-Grehl et al. (2024) emphasize that recognition of identity diversity, including cultural and sexual backgrounds, in teaching approaches can support the formation of a holistic STEM identity.

However, the education system also poses challenges when its approach is exclusive or solely merit-oriented. Galanti and Holincheck (2025) demonstrate that pressure to excel in exams and a meritocratic culture have led to identity conflicts among high-achieving female students who receive limited social recognition. The role of teachers in creating a supportive learning environment is also recognized as important. A study by Edelen et al. (2024) suggests that reflective dialogue approaches and techniques, such as photo-elicitation, help students express their experiences and subsequently build self-agency in STEM fields. Additionally, access to identity-focused mentoring programs, as reported by Campbell-Montalvo et al. (2022), has proven to have a positive impact on female students from sexual and ethnic minority groups. Overall, an inclusive, empathetic, and responsive education system that addresses students' needs is a solid foundation for the development of resilient STEM identities.

The school community, as a daily social space for students, also has a significant impact on their identity formation. Based on 16 articles reviewed, the roles of teachers, peers, school organizational structures, and co-curricular programs all contribute to supporting or hindering the development of female students' STEM identity. Edelen et al. (2024) found that teachers who create space for students to express themselves and reflect help build their confidence in their role in STEM. Collaboration between schools and communities, as demonstrated in the study by Birney and McNamara (2022), also shows that community recovery projects led by teachers help students better understand the real-world applications of STEM. Peers and the social environment among students also play a significant role. Calkins et al. (2023) found that participation in sports and group activities strengthens girls' confidence in their abilities in competitive contexts.

Meanwhile, formal and informal mentoring programs, as reported by Balasubramanian et al. (2023) and Campbell-Montalvo et al. (2022), offer consistent psychosocial support, particularly to students who are underrepresented in their school communities. However, some articles also suggest that school communities can be a source of conflict if they fail to address stereotypes and discrimination thoroughly (Corbett et al., 2024). Therefore, transforming school culture towards equity and inclusivity is essential to ensure that school communities function as enablers rather than barriers to female students' STEM identities.

Family involvement is also recognized as a fundamental factor in building motivation and a sense of competence among female students. Five articles reviewed demonstrate that family support, in the form of emotional support, social legitimacy, and early exposure to STEM, has a direct influence on the formation of student identity. Rillero et al. (2025) found that project-based approaches involving parents helped strengthen students' confidence and sense of ownership over the learning process. Dou et al. (2019) reported that science-related conversations and informal visits, such as museum trips, play a role in shaping STEM cultural capital from an early age.

In the context of ethnic minorities, a study by Ackert et al. (2021) found that families who set high expectations and provide consistent support build students' resilience to stay in STEM education despite systemic challenges. Godec et al. (2024) introduced the concept of ‘family science capital’, showing how household experiences such as kitchen experiments or reading science books together shape early perceptions of STEM as something appropriate and accessible. Furthermore, Prieto et al. (2017) demonstrated that parents' selection of activities

and toys during early childhood influences girls' self-efficacy in mathematics. This highlights that families are not only emotional sources but also early symbolic spaces in the process of self-identification as STEM individuals.

Finally, students themselves, as individuals, have the power to influence and shape their identities through internal characteristics such as interests, motivation, self-efficacy, career aspirations, and resilience. Based on 23 analyzed articles, individual factors are the primary drivers and ultimate determinants of whether students choose to stay in or leave STEM fields. Zhao et al. (2024) and Starr et al. (2020) found that high interest and positive experiences in science activities have a direct impact on intrinsic motivation and self-concept. Self-efficacy also plays a crucial role in determining students' courage to face challenges. Clark et al. (2016) and Seyranian et al. (2018) found that female students who are confident in their abilities in STEM subjects demonstrate better academic achievement and more stable emotional well-being. Clear career aspirations, such as the desire to become a scientist or engineer, also strengthen the identity formation process, as demonstrated by Mulvey et al. (2023) and Fan et al. (2023). Additionally, resilience in the face of social pressure and stereotypes is a key factor. Campbell-Montalvo et al. (2022) found that LGBTQ+ students who can build support networks and engage in self-reflection are more likely to maintain their STEM identity. This suggests that while social context plays a significant role, students' ability to process, adapt, and construct their own narratives is central to a stable and enduring identity.

In conclusion, the formation of STEM identity among female students is the result of complex interactions among five main factors: macro society, the education system, the school community, family involvement, and the individual herself. Each factor contributes in a unique and interconnected way, reflecting the need for a systemic, interdisciplinary, and inclusive approach to support. To strengthen women's participation in STEM, all five factors must be addressed in a balanced and integrated manner within educational foundations, social interventions, and identity-building strategies for today's female students.

DISCUSSION

This study systematically examines the formation of STEM identity among female students from two main perspectives: identity dimensions and environmental factors that influence it. Based on the analysis of 51 carefully selected academic articles using the Systematic Literature Review (SLR) method, four main dimensions have been identified as the core of STEM identity: interest, competence and achievement, social recognition, and a sense of belonging. All these dimensions are interrelated and serve as indicators of whether female students perceive themselves as part of the STEM community.

The first dimension, interest, is recognized as the initial catalyst that encourages female students to engage in STEM fields. Studies show that interest develops when learning is closely related to real-life experiences, responsive to cultural contexts, and delivered through enjoyable and interactive experiences (Milton et al., 2023; Aladé et al., 2022). The second dimension, competence and achievement, refers to students' ability to feel confident and motivated in completing tasks and obtaining academic recognition. However, Galanti and Holincheck (2025) found that even when high achievement is attained, barriers in terms of perceptions and social stereotypes still prevent female students from fully identifying themselves as STEM individuals.

Furthermore, the third dimension, social recognition, functions as external validation that strengthens or weakens identity formation. When students receive recognition from teachers, peers, the media, and society, they are more likely to maintain their commitment to STEM (Gurkan & Echazarreta-Soler, 2023). The final dimension is a sense of belonging, which is the feeling of being accepted and valued in the learning environment or scientific community (Dost, 2024). Without this dimension, interest and achievement do not necessarily lead to stable identity development.

In addition to these dimensions, this study also identifies five main factors that act as external influences on the formation of STEM identity. First, macro society plays a significant role in shaping initial perceptions through popular culture, mass media, and social norms (Steinke et al., 2024; Phillips et al., 2022). Gender stereotypes in the media can hinder the aspirations of female students, while the visualization of female scientists on social media can strengthen their enthusiasm and confidence.

Secondly, the education system plays the most direct structural role in providing students with opportunities to develop interests and competencies in STEM (Star et al., 2020; Singer et al., 2020). Galanti and Holincheck (2025) found that the effectiveness of this system is highly dependent on an inclusive curriculum, gender-responsive teaching approaches, and teachers' willingness to provide a space for students to voice their experiences. Third, school communities, such as teacher-student relationships, peer relationships, and co-curricular activities, strive to build or shape STEM identity, depending on whether the school environment supports inclusivity and authenticity.

Furthermore, family involvement is recognized as crucial for early exposure, reinforcement of values, and emotional support for girls' aspirations (Dou et al., 2019). Families that actively support informal science activities or provide social legitimacy to STEM careers contribute to the development of their daughters' self-identity. The fifth factor is the students themselves as individuals. Intrinsic interest, self-efficacy, career aspirations, and resilience are the main determinants that motivate students to stay on the STEM path, even when faced with social barriers (Clark et al., 2016; Seyranian et al., 2018; Mulvet et al., 2023).

In conclusion, the findings of this study indicate that the formation of STEM identity is the result of complex interactions between internal factors and the social environment. Success in nurturing more female students in STEM fields requires interventions at various levels—from media and education to classroom approaches and family support. This study recommends that all stakeholders, including policymakers, teachers, parents, and researchers, play an active role in building a supportive ecosystem that nurtures the dimensions of STEM identity and leverages the influence of the five key factors identified.

Limitations of the study

This study was conducted with consideration of several methodological limitations to ensure the accuracy and suitability of sources in relation to the study's objectives and issues. The research process was conducted thoroughly by reviewing previous empirical studies focusing on the main topic, namely STEM identity, and selecting only studies from prestigious databases such as Web of Science (WoS) and SCOPUS. This selection aims to ensure that the quality of publications aligns with international standards (Depaepe et al., 2013). In addition, the use of search terms that encompass the dimensions of STEM identity, such as competence, recognition, achievement, motivation, and sense of belonging, allows researchers to access studies that are genuinely relevant to the scope of the investigation. The primary focus is on the female population, in line with the study's objective of examining STEM identity among female students. Only articles published between 2000 and 2024 were used to ensure relevance to contemporary issues. Additional criteria included selecting journals that have undergone peer review to ensure the credibility of the findings. A Systematic Literature Review (SLR) approach was chosen because it allows for a comprehensive synthesis of a large number of studies with high methodological rigor (Zhai et al., 2024).

CONCLUSION

Based on the findings of this systematic literature review (SLR) that examined the characteristics of STEM identity formation among female students and the factors influencing it, a further study should take the form of an empirical study using a mixed methods approach to holistically explore the actual experiences, motivations, and challenges faced by female students in developing their STEM identity. This investigation can be conducted longitudinally to trace the development of STEM identity from elementary school to high school or university, while identifying significant turning points in the trajectory of identity formation (Carlone & Johnson, 2007; Dou et al., 2019). Additionally, comparative studies between socio-economic backgrounds, ethnic groups, or geographical locations (such as urban vs. rural) can be conducted to identify structural disparities that may hinder the development of a strong STEM identity among female students (Wong & Copsey-Blake, 2023). Emphasis can also be placed on the role of teachers, school communities, and gender-equitable pedagogical strategies in supporting the development of such identities (Seyranian et al., 2018). This study may indirectly contribute to the design of more effective educational interventions, in line with the objectives of the Malaysian Education Development Plan 2013–2025 to strengthen equity and justice in STEM education.

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