Chapter 6
Gender-Inclusive Pedagogies in Computer Science Education:
Insights, Implications, and Future Directions

Narcisan S. Galamiton
Cebu Technological University, Philippines

Mary Jane C. Sim
Cebu Technological University, Philippines

Dharel P. Acut
https://orcid.org/0000-0002-9608-1292
Cebu Technological University, Philippines

Damola Olugbade
https://orcid.org/0000-0003-3938-6273
First Technical University, Nigeria

Asegul Hulus
https://orcid.org/0000-0001-8797-450X
University of Nicosia, Cyprus

Ramesh Chander Sharma
https://orcid.org/0000-0002-1371-1157
Dr. B.R. Ambedkar University, Delhi, India

Ari Happonen
https://orcid.org/0000-0003-0744-1776
LUT University, Finland

Manuel B. Garcia
https://orcid.org/0000-0003-2615-422X
FEU Institute of Technology, Philippines

ABSTRACT

Despite growing demand for computing professionals, women remain significantly underrepresented in computer science education and technology careers. This chapter presents a narrative review of literature on gender-inclusive pedagogies, examining classroom practices, curriculum design, assessment strategies, mentorship,

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and institutional initiatives that support female learners' engagement, persistence, and sense of belonging. Drawing on international and regional studies, the review identifies effective approaches such as collaborative learning, identity-affirming and real-world curricula, formative assessment, and structured support systems, while highlighting persistent gaps including Western-centric perspectives, limited intersectional analyses, and misalignment between policy rhetoric and classroom practice. Grounded in technofeminist theory, the chapter discusses implications for educators, institutions, policymakers, and future research aimed at advancing equity in computing education.

INTRODUCTION

In an era defined by rapid digital transformation, gender disparities in computing remain a persistent global concern (Ashlock & Tufekci, 2024; Fietta et al., 2023; Perez-Felkner et al., 2024). Despite substantial progress in access to education and workforce participation, women continue to be underrepresented in computing fields both in academia and in industry. According to the World Economic Forum (2023), women comprise only about 28% of the global STEM workforce, with their participation particularly low in computing-related roles. In the technology industry, women account for roughly 25% of technical positions and an even smaller share of leadership roles (Forbes, 2024). Within software development, the imbalance is even more pronounced as over 90% of developers identify as male.

These figures are often interpreted through the lens of a persistent "leaky pipeline," where women's representation diminishes progressively from education to employment, as access to computing fields remains shaped by gendered cultural capital, socialization patterns, and institutional pathways that disproportionately advantage male-dominated trajectories. However, recent critical scholarship cautions that this metaphor risks producing static and deficit-oriented accounts of women's participation in computing. Vitores and Gil-Juárez (2016) argue that decades of research framed around the leaky pipeline have paradoxically contributed to a sense of inevitability by focusing on women's attrition rather than interrogating how computing itself is socially constructed and institutionally organized. They highlight that, despite growing participation of women across most STEM fields, computing remains an outlier and that the problem lies with entrenched disciplinary cultures, research assumptions, and policy framings that continue to reproduce gendered exclusions.

These global patterns are mirrored at regional levels. Within the European Union, for instance, women comprise 52% of the overall science and technology workforce yet remain significantly underrepresented in information and communication technology (ICT) professions (Eurostat, 2024). Eurostat (2023) data show that men account for approximately 84% of ICT specialists, leaving women with only a 15.9% share. The European Institute for Gender Equality (2024) links this imbalance to persistent sociocultural stereotypes, unequal access to digital skills development, and the limited presence of women in technology-related leadership roles. Likewise, the United Nations Economic Commission for Europe (2025) notes that despite progressive policy frameworks, structural inequalities continue to shape women's participation across education, employment, and innovation systems in Europe.

Similar dynamics are evident across Asia and the Pacific, where gendered barriers to digital access and participation continue to constrain women's engagement with technology. Centuries of patriarchy, discrimination, and harmful stereotypes have shaped a persistent digital gender divide, with only 54% of women in Asia and the Pacific having digital access (United Nations Economic and Social Commission for Asia and the Pacific, 2023). Women and girls remain less likely than men and boys to use the internet or own a smartphone, and gender-based violence (both offline and increasingly online) further compounds their exclusion. Consistent with these findings, Galpaya and Zainudeen (2022) emphasize that barriers extend beyond connectivity, encompassing limited opportunities for digital skill development, constrained participation in technology-related learning, and socio-cultural expectations that discourage engagement with ICT fields. UNICEF (2023) likewise reports that in low-income countries, 90% of adolescent girls and young women aged 15–24 remain offline compared to 78% of boys and young men, with the largest gap in South Asia, favoring males by 27 percentage points. Furthermore, for every 100 male youth possessing digital skills, only 65 female youth do, and across 41 countries, young women are nearly 13% less likely to own a mobile phone. These intersecting disadvantages reveal that the gender gap in ICT extends far beyond issues of access or infrastructure. Instead, it is deeply rooted in structural inequalities and sociocultural barriers that shape women's digital participation and perpetuate broader patterns of exclusion in computing and technology-related fields (Kovaleva et al., 2024a; Kovaleva et al., 2024c).

While the literature identifies a range of pedagogical, institutional, and policy-oriented approaches that can foster greater inclusivity for women in higher education computing contexts (Ashlock & Tufekci, 2024; Fietta et al., 2023; Lopes, 2022; Perez-Felkner et al., 2024; Wu & Uttal, 2024), such practices remain unevenly adopted and are far from being embedded as standard practice. This systemic exclusion from digital participation also translates into underrepresentation within the technology workforce. A persistent paradox emerges in that, although users of technology are nearly evenly distributed by gender, the creators of technology (e.g., software engineers, systems designers, and computing professionals) remain predominantly male (European Institute for Gender Equality, 2024; Eurostat, 2023). This imbalance has far-reaching implications. When technological systems are designed primarily by men, the resulting products, algorithms, and digital infrastructures risk embedding implicit gender biases (DeCook, 2020). Design decisions shaped by narrow assumptions about users can marginalize diverse users in subtle but consequential ways. Research in inclusive and user-centered design demonstrates that broadening design perspectives not only improves equity but also enhances usability, efficiency, and sustainability for all users. In this sense, increasing diversity among computing professionals is not solely a matter of representation but a critical condition for producing technologies that are responsive to evolving practices, contexts, and user needs.

In the context of education, gendered disparities in computing are visible early in the pipeline. Although girls and women are active technology users, they remain underrepresented in computing programs at secondary and tertiary levels (UNESCO, 2017). Studies attribute this to a combination of factors including cultural stereotypes, lack of role models, implicit classroom biases, and learning environments that unconsciously privilege male participation (Adams & Morgan, 2021; Kurti et al., 2024; Sulla et al., 2025). Pedagogical practices that emphasize competition and individual performance may further discourage participation among female learners, while inclusive teaching strategies (e.g., collaborative learning, mentoring, and real-world project engagement) are shown to improve belonging and persistence (Dost, 2024; Guo et al., 2025). These patterns highlight the urgent need to examine not only who participates in computing education but also how pedagogical structures, classroom cultures, and curriculum designs shape participation, persistence, and inclusion by reproducing or challenging gendered norms.

MAIN FOCUS OF THE CHAPTER

This chapter addresses a critical gap in computing education research by synthesizing existing scholarship on gender disparities with a focused examination of gender-inclusive pedagogical approaches in computer science education. While prior studies have extensively documented women's underrepresentation in computing, less attention has been given to systematically analyzing which pedagogical practices effectively foster inclusion, belonging, and persistence among female learners, and why these practices work across diverse educational contexts. Moreover, existing reviews often privilege structural or policy-level explanations, leaving pedagogical dynamics underexplored. Responding to this gap, the chapter adopts a narrative review supported by expert-informed synthesis to (1) identify and categorize gender-inclusive pedagogical strategies reported in the literature, (2) examine how these approaches address sociocultural, instructional, and institutional barriers in computing education, and (3) distill actionable implications for educators, institutions, and policymakers. Foregrounding pedagogy as a central lever for change, this chapter aims to contribute a coherent, practice-oriented framework that informs inclusive teaching, curriculum design, and future research directions in computer science education.

METHODOLOGY

Approach and Analytical Lens

This chapter adopts a narrative review approach with expert-informed synthesis to examine gender-inclusive pedagogies in computer science education. Unlike systematic or PRISMA-style reviews that prioritize exhaustive coverage and procedural replication (Page et al., 2021), a narrative review foregrounds conceptual depth, interpretive coherence, and pedagogical relevance. This approach is particularly suited to examining the multifaceted and context-dependent factors shaping women's participation, persistence, and progression in computing education and related technology pathways (Kovaleva et al., 2023).

The synthesis draws on a broad corpus of empirical studies, conceptual and theoretical papers, policy documents, and practitioner-oriented literature. Importantly, the review is informed by the combined professional and research expertise of the authors who collectively bring approximately 5 to 25 years of experience in higher education teaching, research, curriculum development, and academic leadership within computer science, information technology, and STEM education. This expertise includes sustained engagement in gender equity work, including current administrative leadership roles such as directing institutional Gender and Development (GAD) initiatives, which provide direct insight into policy implementation, faculty development, and equity-driven educational reform. This cumulative knowledge, spanning more than two decades of engagement with gender-focused and multi-gendered educational settings at national and international levels, supports a critical and contextually grounded interpretation of the literature. While the review does not follow a formal PRISMA protocol, principles of transparency, rigor, and reflexivity associated with systematic reviewing were applied through collaborative source selection, cross-checking of key themes, and iterative synthesis informed by the authors' diverse educational experiences.

The analytical framework is guided by technofeminist theory and gender-inclusive pedagogical perspectives. Technofeminism, as articulated by Wajcman (2004), conceptualizes technology and technological knowledge as socially constructed rather than neutral, shaped by historically situated gendered power relations. Applied to computing education, this lens foregrounds how curricula, classroom cultures, assessment practices, and institutional norms may reproduce exclusionary assumptions or, alternatively, serve as sites for resistance and transformation. Complementing this perspective, gender-inclusive pedagogy emphasizes relational, collaborative, and equity-oriented instructional approaches, including mentorship, project-based and community-engaged learning, and culturally responsive teaching (Dost, 2024; Guo et al., 2025). Across the chapter, the synthesis is organized around three interrelated analytical dimensions: (1) pedagogical practices, (2) learning environments and cultures, and (3) structural and sociocultural conditions that intersect with classroom-level practices to shape female learners' engagement, identity formation, and persistence in computer science education.

Conceptual and Theoretical Perspectives

The conceptual foundation of this review draws on interdisciplinary scholarship from computing education, gender studies, and STEM pedagogy. Technofeminism provides a lens for interpreting how gendered power dynamics permeate technology development, learning environments, and classroom interactions (DeCook, 2020; Wajcman, 2004). The chapter also incorporates social constructivist principles (Vygotsky, 1978), which position learning as socially situated and relational, emphasizing collaborative knowledge-building and peer interaction as key mechanisms for fostering inclusion. Gender-inclusive pedagogy frameworks further inform the analysis, highlighting strategies that enhance belonging, representation, and equity in STEM classrooms (Kurti et al., 2024; Sulla et al., 2025). These frameworks guide the identification and interpretation of pedagogical interventions (e.g., collaborative problem-solving, real-world projects, mentoring, and inclusive assessment practices) enabling the synthesis to move beyond descriptive accounts toward actionable insights for educational practice and policy.

Literature Search and Source Selection

Relevant literature was identified through a targeted search strategy across multiple databases, including Scopus, Web of Science, ERIC, and Google Scholar. Keywords included combinations of "*gender-inclusive pedagogy*," "*female students*," "*computing education*," "*STEM*," "*classroom inclusion*," and "*technofeminism*." The search prioritized sources published in the last decade, supplemented with foundational and policy-oriented documents from organizations such as UNESCO, the European Institute for Gender Equality (EIGE), UNICEF, and the World Economic Forum. Selection of studies followed a structured, expert-informed process. Initially, titles and abstracts were screened for relevance to gender-inclusive pedagogical practices, learning outcomes, and equity in computing education. Full texts were then critically appraised using a checklist that assessed three dimensions: relevance, methodological rigor, and applicability to higher education contexts. The scoring was conducted independently by three contributing authors, and final ratings were determined through inter-rater agreement discussions to ensure consistency and reliability. Critical appraisal techniques (e.g., evaluation of study design, sample characteristics, analytical methods, and context specificity) were applied to ensure inclusion of high-quality and impactful studies. Both empirical studies and conceptual or theoretical contributions were included, reflecting the contributors' combined 5–25 years of experience in national and international gender-focused and multi-gendered educational settings.

The selected studies are summarized in Table 1, which presents the study type, key contributions, checklist scores, and inclusion rationale. The literature synthesis is thematic and interpretive, aiming to identify patterns, gaps, and tensions across contexts rather than quantify studies or produce meta-analytic estimates. This approach enables a critical, practice-oriented examination of gender-inclusive pedagogical strategies and provides a foundation for actionable recommendations for educators, institutions, and policymakers.

Table 1. Summary of Selected Literature on Gender-Inclusive Pedagogical Practices in Computing Education

No	Author (s) & Year	Key Focus/Contribution	Checklist Scores	Inclusion Rationale
1	Choi (2014)	Compares gender pair combinations in pair programming; examines collaboration and performance outcomes	Relevance – 3 Rigor – 3 Applicability – 3	Demonstrates how structured pairing can reduce isolation, support peer learning, and enhance equitable participation in CS classrooms
2	Lee (2015)	Examines the effect of secondary-level CS education on STEM major selection in postsecondary institutions	Relevance – 3 Rigor – 2 Applicability – 3	Highlights how early CS learning environments influence female students' persistence in STEM; informs design of inclusive secondary CS curricula
3	Lubin (2016)	Provides frameworks for intentional ICT curriculum and pedagogy	Relevance – 3 Rigor – 2 Applicability – 3	Offers foundational principles for designing inclusive computing curricula and instructional practices
4	Spieler et al. (2018)	Analyzes female teenagers' coding performance; identifies pedagogical practices that reinforce gender equality	Relevance – 3 Rigor – 3 Applicability – 3	Provides evidence on classroom practices that support female learners; supports identity-affirming, engagement and inclusive strategies

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Table 1. Continued

No	Author (s) & Year	Key Focus/Contribution	Checklist Scores	Inclusion Rationale
5	Arawjo and Mogos (2021)	Discusses community-oriented computing projects and intercultural perspectives	Relevance – 3 Rigor – 2 Applicability – 3	Provides guidance for embedding social relevance and real-world problem-solving in collaborative pedagogies
6	Kallia and Cutts (2021)	Examines inequalities in CS participation using a Bourdieusian lens; identifies structural and cultural barriers	Relevance – 3 Rigor – 3 Applicability – 3	Highlights the sociocultural dynamics influencing female learners' access and belonging in computing; informs identity-affirming curriculum design
7	Salguero et al. (2021)	Identifies sources of student struggle in early CS courses, highlighting barriers for female learners	Relevance – 3 Rigor – 3 Applicability – 3	Provides insights into structural and instructional factors that affect persistence and participation, informing support strategies
8	Davis et al. (2022)	Explores educators' needs for building inclusive classrooms; identifies strategies for policy and practice	Relevance – 3 Rigor – 3 Applicability – 3	Directly addresses inclusive classroom practices, teacher support, and policy implications; highly relevant for fostering belonging and engagement
9	Kovaleva et al. (2022c)	Explores gender balance strategies in intensive CS events; identifies inclusive practices for female participation	Relevance – 3 Rigor – 2 Applicability – 3	Highlights practical applications of collaborative pedagogies in short-term, high-intensity educational settings, supporting inclusion and peer support
10	Kovaleva et al. (2022a)	Analyzes pros and cons of gender-neutral hackathon design; addresses implementation challenges	Relevance – 3 Rigor – 2 Applicability – 3	Informs best practices for gender-balanced events, demonstrating the need to balance inclusivity with practical constraints
11	Kovaleva et al. (2022b)	Explores design of gender-neutral software engineering programs; identifies stereotypes and social pressures	Relevance – 3 Rigor – 2 Applicability – 3	Supports broader program-level design insights; highlights systemic approaches to making CS and engineering programs inclusive for all genders
12	Lagesen et al. (2021)	Discusses inclusion of women in ICT engineering; evaluates curriculum and program design lessons	Relevance – 3 Rigor – 2 Applicability – 3	Highlights the role of curriculum representation, diverse role models, and program structures in supporting female learners
13	Yates and Plagnol (2021)	Investigates female CS students' experiences in UK universities; focuses on classroom climate and curriculum impact	Relevance – 3 Rigor – 3 Applicability – 3	Provides qualitative insight into authentic student experiences, reinforcing the need for inclusive, socially relevant, and representative curriculum design

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Table 1. Continued

No	Author (s) & Year	Key Focus/Contribution	Checklist Scores	Inclusion Rationale
14	Patel et al. (2023)	Examines implementation of inclusive software design practices in CS courses	Relevance – 3 Rigor – 3 Applicability – 3	Direct evidence on strategies to integrate gender-inclusive and socially relevant examples into computing curriculum
15	Garcia et al. (2024)	Presents the Matchmaker inclusive design curriculum to enable faculty to teach inclusive design across undergrad CS	Relevance – 3 Rigor – 3 Applicability – 3	Presents the Matchmaker inclusive design curriculum to enable faculty to teach inclusive design across undergrad CS
16	Kovaleva et al. (2024b)	Provides evidence-based strategies for female-inclusive CS program design	Relevance – 3 Rigor – 2 Applicability – 3	Summarizes actionable design practices for inclusive computing education, bridging curriculum, pedagogy, and institutional policies
17	Ko and Stephens-Martinez (2024)	Characterizes students' individual help-seeking approaches in computing education	Relevance – 3 Rigor – 3 Applicability – 3	Shows how collaborative structures like pair programming normalize help-seeking, reduce isolation, and improve retention for female learners
18	Kurti et al. (2024)	Investigates women's motivations for pursuing ICT higher education; examines barriers and enablers	Relevance – 3 Rigor – 2 Applicability – 3	Offers insights into female learners' pathways in higher education CS programs; informs identity-affirming strategies and institutional initiatives
19	Napier and Bourgeois (2024)	Evaluates a cohort-based community for Black women in computing	Relevance – 3 Rigor – 3 Applicability – 3	Highlights the value of learning communities and peer networks for fostering identity, belonging, and retention
20	O'Brien et al. (2025)	Assesses gender bias in software used for CS and software engineering education	Relevance – 3 Rigor – 3 Applicability – 3	Highlights how instructional tools themselves can embed bias; informs equitable software and assessment practices
21	Ackerman et al. (2025)	Explores an internship for teaching design research, emphasizing real-world engagement	Relevance – 3 Rigor – 3 Applicability – 3	Shows how experiential learning and industry-linked programs provide mentorship and role modeling to support female students' professional pathways
22	Garcia (2025a)	Uses self-coded digital portfolios as authentic assessment in web development courses	Relevance – 3 Rigor – 3 Applicability – 3	Shows alternative assessment methods that value diverse learning pathways and competencies beyond exams
23	Heath et al. (2025)	FLARE framework for code comprehension and formative assessment in block-based programming	Relevance – 3 Rigor – 3 Applicability – 3	Demonstrates structured formative assessment strategies that promote inclusive learning and iterative feedback

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Table 1. Continued

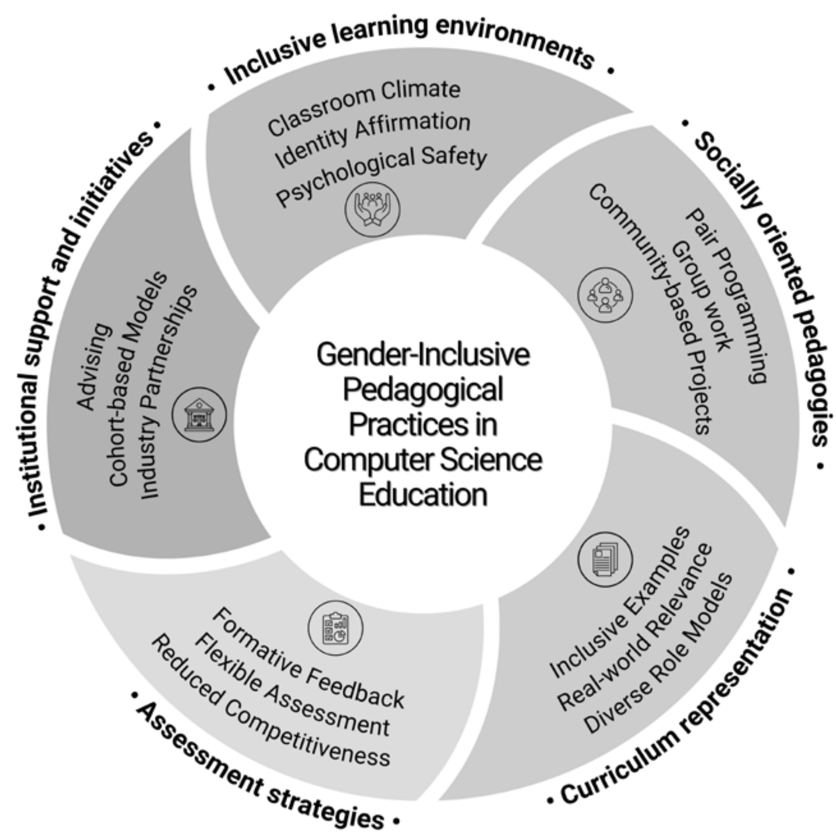
No	Author (s) & Year	Key Focus/Contribution	Checklist Scores	Inclusion Rationale
24	McLaughlin et al. (2025)	Explores mentors' and mentees' experiences in K-12 CS classrooms	Relevance – 3 Rigor – 3 Applicability – 3	Demonstrates the impact of structured mentoring on confidence, belonging, and skill development for female students
25	Moura et al. (2025)	Explores cooperation and competition dynamics in computing education	Relevance – 3 Rigor – 3 Applicability – 3	Explores cooperation and competition dynamics in computing education
26	O'Leary et al. (2025)	Evaluates "Care Pathways," a culturally informed co-design program for Black American women	Relevance – 3 Rigor – 3 Applicability – 3	Illustrates community-engaged initiatives that reinforce mentorship, inclusion, and socially responsive computing education
27	Robinson (2025)	Investigates effects of mentoring programs for CS students with disabilities	Relevance – 3 Rigor – 3 Applicability – 3	Provides evidence of inclusive mentorship approaches that support underrepresented groups, including female learners with intersecting identities
28	Wali and Hooshangi (2025)	Examines barriers, success metrics, and research gaps for transfer students in CS	Relevance – 3 Rigor – 3 Applicability – 3	Emphasizes institutional factors and structural supports needed to promote equity and inclusion for female learners and nontraditional students
29	Yeom et al. (2025)	Examines gender disparities in collaborative learning; highlights effective group-based pedagogies	Relevance – 3 Rigor – 3 Applicability – 3	Emphasizes group and project-based approaches to enhance belonging, confidence, and participation of female learners
30	Palvia et al. (2026)	Explores global patterns of women leaving IT professions; analyzes curricular and cultural factors	Relevance – 3 Rigor – 2 Applicability – 3	Emphasizes the importance of sustained representation and curriculum strategies to retain women in computing fields

Notes. Checklist scores range from 1 to 3, with 1 = low, 2 = medium, and 3 = high, reflecting relevance, methodological rigor, and applicability. Abbreviations used: CS = Computer Science; ICT = Information and Communication Technology; IT = Information Technology; STEM = Science, Technology, Engineering, and Mathematics.

SYNTHESIS OF GENDER-INCLUSIVE PEDAGOGICAL PRACTICES

This section synthesizes findings from the reviewed literature to articulate key pedagogical practices that support gender inclusion in computer science education. Rather than treating inclusion as a single instructional strategy, the synthesis conceptualizes gender-inclusive pedagogy as a multilevel and interconnected set of practices that operate across classroom environments, instructional approaches, curriculum design, assessment, and institutional support structures. As illustrated in Figure 1, these practices collectively shape learners' experiences by addressing both the social and structural dimensions of participation in computing. The figure highlights five interrelated domains that emerged consistently across studies, underscoring that fostering gender inclusion requires coordinated efforts at multiple levels of the educational ecosystem. The subsections that follow elaborate on each domain, beginning with the creation of inclusive learning environments and a strong sense of belonging, which the literature identifies as a foundational condition for equitable participation in computer science.

Figure 1. Multilevel Gender-Inclusive Pedagogical Practices in Computer Science Education



Creating Inclusive Learning Environments and Sense of Belonging

Creating inclusive learning environments is a foundational component of gender-inclusive pedagogies in computer science education, particularly in fostering a sense of belonging among female learners. Research consistently shows that classroom climate plays a critical role in shaping students' engagement, persistence, and identity development in computing fields (Cheryan et al., 2017; Davis et al., 2022; Kurti et al., 2024). When learning environments are perceived as welcoming, respectful, and inclusive, female students are more likely to participate actively, take intellectual risks, and envision themselves as legitimate members of the computing community (Spieler & Girvan, 2025).

A central dimension of inclusive classroom climate is identity affirmation, wherein students' gender identities, experiences, and perspectives are recognized and valued within the learning process. Studies indicate that pedagogical practices that normalize diversity (e.g., inclusive language use, diverse examples and case studies, and visible representation of women in computing) can counteract stereotypes that frame computing as a masculine domain (Cheryan et al., 2017; Fisher & Margolis, 2003). Identity-affirming environments enable female learners to reconcile their personal identities with their emerging disciplinary identities, reducing feelings of alienation and stereotype threat that often contribute to attrition in computing programs (Sulla et al., 2025).

Psychological safety further underpins inclusive learning environments by allowing students to express uncertainty, ask questions, and engage in problem-solving without fear of judgment or marginalization (Mangubat et al., 2025). Competitive, high-stakes, or error-intolerant classroom cultures have been shown to disproportionately discourage female participation, reinforcing perceptions of inadequacy and exclusion (Dost, 2024; Lee, 2015). In contrast, pedagogical approaches that emphasize collaboration, formative feedback, and iterative learning promote a shared sense of responsibility and mutual respect, which supports confidence-building and sustained engagement (Guo et al., 2025; Valderama et al., 2022). From a technofeminist perspective, these practices challenge entrenched power hierarchies in computing classrooms by redistributing authority and validating multiple ways of knowing (DeCook, 2020; Wajcman, 2009).

Collectively, the literature underscores that inclusive learning environments are not merely supportive add-ons but are integral to effective computing pedagogy. Cultivating positive classroom climates, affirming diverse identities, and fostering psychological safety can disrupt exclusionary norms and create conditions that enable female learners to thrive. Such environments form a critical foundation for subsequent pedagogical innovations aimed at promoting equity, persistence, and success in computer science education.

Collaborative and Socially Oriented Pedagogies

Collaborative and socially oriented pedagogies have been widely identified as effective strategies for promoting gender inclusion in computer science education. Traditional computing instruction often emphasizes individual performance, competition, and solitary problem-solving, practices that may inadvertently marginalize students who value relational and social learning contexts (Cheryan et al., 2017; Fisher & Margolis, 2003). In contrast, pedagogical approaches that foreground collaboration and shared knowledge construction align more closely with inclusive learning principles and have been shown to enhance engagement, confidence, and persistence among female learners.

Pair programming is one of the most extensively studied collaborative practices in computing education (Garcia, 2023a). Research suggests that structured pair programming, when intentionally implemented, supports equitable participation, reduces anxiety, and fosters peer support, particularly for students who may feel less confident in technical environments (Choi, 2014). Also, in the context of intensive educational events such as Code Camps and Hackathons, these practices provide opportunities to promote more gender-balanced participation, with peer support, structured pairing, and reduced "working alone" culture serving as key tools for success (Garcia, 2023b; Kovaleva et al., 2022c; Revano & Garcia, 2020). Female students often report that pair programming mitigates feelings of isolation and helps normalize help-seeking behaviors, contributing to stronger learning outcomes and increased retention in computing courses (Ko & Stephens-Martinez, 2024). However, studies also caution that without clear role rotation and instructor guidance, gendered power dynamics may persist within pairs, indicating yet again that proper implementations must consider both the advantages and limitations of running educational events, courses, and programs in gender-specific ways (Kovaleva et al., 2022a; Lubin, 2016).

Beyond dyadic collaboration, group work and peer learning create opportunities for dialogue, collective problem-solving, and distributed expertise. Social constructivist perspectives emphasize that learning is inherently social, shaped through interaction and shared meaning-making (Vygotsky, 1978). In computing classrooms, group-based activities enable female learners to engage in multiple roles, such as planning, debugging, and explaining (Yeom et al., 2025). When instructors explicitly value communication, reflection, and teamwork, these pedagogies challenge dominant norms that equate competence solely with speed or individual mastery. Community-based and project-oriented learning further extend collaborative pedagogies by situating computing within meaningful, real-world contexts. Projects that address social issues, local community needs, or interdisciplinary challenges have been shown to increase relevance and motivation among female students, who often express a desire to see the social impact of computing work (Arawjo & Mogos, 2021; Dost, 2024; Kurti et al., 2024). From a technofeminist perspective, such approaches disrupt the notion of computing as a purely technical endeavor, reframing it as a socially embedded practice shaped by values, ethics, and human needs (DeCook, 2020; Wajcman, 2004).

Collectively, collaborative and socially oriented pedagogies foster learning environments that value interdependence, dialogue, and shared agency (Sharma et al., 2021). When thoughtfully designed and supported, these approaches not only enhance learning outcomes but also contribute to a stronger sense of belonging and identity among female learners, reinforcing their sustained participation in computer science education. On a larger scope, what is needed are considerations, means, and methods combined into broader, gender-neutral program designs that make engineering and computing programs less stereotypical, more inclusive of all genders, and genuinely "designed for all," inspired and guided by inclusive principles (Kovaleva et al., 2022b, 2024b).

Curriculum Design and Representation

Curriculum design plays a critical role in shaping students' perceptions of who belongs in computer science and whose knowledge and experiences are valued. Research consistently demonstrates that curricula which rely on narrow, abstract, or gender-stereotypical examples can inadvertently reinforce the perception of computing as a masculine and socially detached field (Fisher & Margolis, 2003; Kallia & Cutts, 2021). In contrast, inclusive curriculum design foregrounds relevance, representation, and contextualized learning, creating opportunities for female learners to meaningfully connect with computing concepts and practices (Garcia et al., 2024; Patel et al., 2023).

One key dimension of inclusive curriculum design is the use of gender-inclusive and socially relevant examples. Studies indicate that when programming tasks and problem sets are situated in real-world contexts (e.g., health, education, sustainability, or community development), female students report higher levels of engagement and perceived value in computing courses (Mills et al., 2024; Peters et al., 2024). These contextualized examples challenge dominant narratives that frame computing as detached from social concerns. Instead, they position computing as a tool for addressing real societal challenges. Education can be connected across multiple domains at the same time (e.g., teaching both the technical aspects of computer science and physical fitness and exercise together; Garcia et al., 2023). From a technofeminist perspective, previously discussed curricular choices resist the notion of technological neutrality by explicitly acknowledging the social implications and ethical dimensions of computing (Wajcman, 2004).

Representation of diverse role models within the curriculum further contributes to gender-inclusive learning environments. Visibility of women and other underrepresented groups in computing (through case studies, biographies, guest speakers, or historical narratives) has been shown to positively influence students' sense of belonging and self-efficacy (Lagesen et al., 2021; Palvia et al., 2026). Exposure to diverse pathways and career trajectories helps disrupt stereotypes about who can succeed in computing, enabling female learners to envision themselves as legitimate contributors to the field. Importantly, research emphasizes that representation must be authentic and sustained, rather than tokenistic, to meaningfully impact student perceptions (Kurti et al., 2024; Yates & Plagnol, 2021).

Inclusive curriculum design also involves critically examining the hidden curriculum, which refers to the implicit values, assumptions, and norms embedded within course content and assessment practices. When curricula privilege speed, individualism, or competition as markers of competence, they may marginalize learners whose strengths lie in collaboration, reflection, or contextual problem-solving (Lunn et al., 2021). Revising curricular structures to value multiple forms of expertise and learning pathways can help counteract exclusionary norms and support more equitable participation.

Collectively, these findings underscore that curriculum design is not a neutral or purely technical endeavor but a powerful site for advancing gender equity in computer science education. Integrating inclusive examples, real-world relevance, and diverse representation allows educators to reshape curricular narratives in ways that affirm female learners' identities, broaden participation, and foster more inclusive computing cultures.

Instructional Practices and Assessment

Instructional practices and assessment strategies are central to shaping students' learning experiences and perceptions of competence in computer science education. Research suggests that traditional assessment models can disproportionately disadvantage female learners by amplifying anxiety, reinforcing stereotype threat, and privileging narrow demonstrations of technical ability (Garcia, 2025b; O'Brien et al., 2025; Spieler et al., 2018). Gender-inclusive pedagogies therefore emphasize instructional approaches that support growth, reflection, and equitable participation.

Formative feedback is a key instructional practice that contributes to inclusive learning environments. Frequent, low-stakes feedback allows students to identify misconceptions, build confidence, and view learning as an iterative process rather than a fixed measure of ability. In computing classrooms, formative feedback mechanisms (e.g., code reviews, reflective journals, and iterative project checkpoints) have been shown to reduce fear of failure and encourage persistence among female learners (Araujo et al., 2025; Garcia & Revano Jr, 2021; Heath et al., 2025; Jamal & Renzella, 2024). Such practices align with social constructivist perspectives by emphasizing learning as a process of continuous improvement supported through dialogue and interaction (Vygotsky, 1978).

Flexible assessment strategies further support gender-inclusive learning by accommodating diverse learning styles, prior experiences, and pathways to demonstrating competence. Alternatives to traditional timed examinations (e.g., portfolio-based assessments, collaborative projects, and applied problem-solving tasks) allow students to showcase both technical skills and higher-order competencies, including communication, collaboration, and ethical reasoning (Córdova-Esparza et al., 2024; Gamusa et al., 2025; Garcia, 2024, 2025a). These approaches challenge deficit-oriented views of ability and broaden the definition of success in computing education.

Reducing excessive competitiveness in instructional settings also plays a critical role in fostering inclusion. Competitive classroom cultures that emphasize speed, individual ranking, or "weed-out" mentalities have been linked to decreased belonging and increased attrition among women in computing programs (Wolz & Taylor, 2019). In contrast, instructional practices that prioritize mastery, cooperation, and shared achievement contribute to psychological safety and sustained engagement (El-Hamamsy et al., 2023; Moura et al., 2025). From a technofeminist perspective, such shifts in assessment and instruction disrupt entrenched power hierarchies by valuing relational, process-oriented, and context-sensitive forms of learning (DeCook, 2020; Wajcman, 2004).

Collectively, the literature highlights that inclusive instructional practices and assessment are not merely evaluative tools but pedagogical levers for advancing gender equity in computer science education. By emphasizing formative feedback, flexibility, and reduced competitiveness, educators can create learning environments that support diverse learners and promote more equitable outcomes.

Mentorship, Support Structures, and Institutional Initiatives

Beyond classroom-level pedagogy, institutional support structures play a critical role in sustaining female students' participation and success in computer science education. Mentorship, advising systems, and structured learning communities provide relational and structural support that complements inclusive instructional practices, addressing both academic and psychosocial dimensions of student experience (Al-Hunaiyyan et al., 2020; Herckis & Oden Choi, 2025). Research consistently shows that the presence of these supports significantly aids female learners in male-dominated computing environments, where isolation and limited access to informal networks can reduce persistence (Salguero et al., 2021).

Mentorship and academic advising have been identified as powerful mechanisms for fostering confidence, career clarity, and belonging among women in computing. Formal mentoring programs (whether peer-based, faculty-led, or industry-linked) offer guidance, role modeling, and affirmation that counteract stereotypes and self-doubt (Stoeger et al., 2013). Studies indicate that access to mentors who share similar identities or experiences can be especially impactful, as they provide visible pathways for success and normalize challenges encountered in computing education (McLaughlin et al., 2025; Robinson, 2025). From a technofeminist perspective, mentorship disrupts hierarchical and exclusionary knowledge structures by legitimizing experiential knowledge and relational forms of support (Wajcman, 2004).

Learning communities and cohort-based models further strengthen institutional efforts toward gender inclusion by creating sustained spaces for peer interaction and collective learning. Programs that intentionally group students across courses or provide dedicated spaces for collaboration have been shown to improve retention, academic performance, and social integration among underrepresented students in computing (Napier & Bourgeois, 2024; Wali & Hooshangi, 2025). These communities promote shared identity formation and reduce the competitive isolation often associated with traditional computing programs.

Institutional initiatives that extend beyond academia, particularly industry partnerships and experiential learning opportunities, also contribute to gender-inclusive pathways in computing. Internships, mentorships with industry professionals, and community-engaged projects expose female students to real-world applications of computing and diverse professional role models, reinforcing the relevance and social impact of their learning (Ackerman et al., 2025; O'Leary et al., 2025). Such initiatives help bridge the gap between education and employment while challenging narrow conceptions of who belongs in the computing workforce.

Collectively, mentorship, support structures, and institutional initiatives function as critical enablers of gender-inclusive computing education. When aligned with inclusive pedagogical practices, these structures contribute to more equitable learning ecosystems that support female learners' persistence, professional identity development, and long-term success in computer science fields.

DISCUSSION

Across the reviewed literature, several consistent patterns emerge regarding what supports female learners' participation and persistence in computer science education. Inclusive classroom climates, collaborative pedagogies, representative curricula, formative assessment practices, and robust mentoring structures repeatedly appear as central enablers of engagement and belonging (Garcia et al., 2024; Heath et al., 2025; McLaughlin et al., 2025; Spieler & Girvan, 2025; Yeom et al., 2025). These practices share a common orientation toward relational learning, contextual relevance, and psychological safety, suggesting that gender inclusion in computing is not driven by isolated interventions but by coherent pedagogical ecosystems. When teaching, assessment, and institutional support are aligned around equity-oriented values, female learners are more likely to develop sustained identification with computing disciplines.

Despite these consistencies, the literature also reveals persistent tensions and gaps in current pedagogical approaches. Many studies document the benefits of inclusive practices while noting uneven implementation, superficial adoption, or resistance within traditionally structured computing programs (Davis et al., 2022; Wolz & Taylor, 2019). For example, collaborative learning may be introduced without addressing underlying power dynamics, leading to gendered role segregation rather than equitable participation (Yeom et al., 2025). Similarly, curricular efforts to diversify examples or role models risk becoming tokenistic when not embedded within broader institutional commitments to inclusion (Garcia et al., 2024; Kurti et al., 2024). These tensions highlight a critical gap between pedagogical intent and pedagogical transformation, underscoring the need to interrogate not only what practices are adopted but how and why they are enacted.

Viewed collectively, gender-inclusive pedagogies fundamentally challenge dominant norms in computer science education, particularly those that privilege individualism, competition, speed, and technical purity as markers of competence (Kallia & Cutts, 2021; Ko & Stephens-Martinez, 2024). Such norms are often framed as value-neutral or meritocratic, yet the literature demonstrates that they disproportionately advantage learners who already align with masculine-coded expectations of computing identity (Lunn et al., 2021; Wolz & Taylor, 2019). Inclusive pedagogical approaches disrupt these assumptions by redefining competence to include collaboration, reflection, ethical awareness, and social impact (Garcia et al., 2024). In doing so, they invite a reimagining of computer science not merely as a technical discipline but as a socially embedded practice shaped by human values and power relations.

These findings strongly align with technofeminist theory, which argues that technologies—and by extension, technological education—are neither neutral nor inevitable but are produced within gendered social structures (DeCook, 2020; Wajcman, 2004). From a technofeminist perspective, inclusive pedagogies function as sites of resistance, making visible the gendered assumptions embedded in computing curricula, assessment regimes, and classroom cultures (Hulus, 2025). By foregrounding lived experience, relational learning, and critical engagement with technology, gender-inclusive pedagogies expose how educational practices can either reproduce or contest existing power hierarchies. Collectively, the literature suggests that advancing gender equity in computer science education requires more than increasing participation or access. It demands a critical reorientation of pedagogical values, one that questions long-standing disciplinary norms and embraces more inclusive, reflexive, and socially responsive forms of computing education. Such a shift has implications not only for who participates in computing but also for how the field itself evolves in response to increasingly diverse societal needs.

Drawing on the convergent patterns and tensions identified across the reviewed literature, the following guidelines are proposed to inform the design, enactment, and evaluation of gender-inclusive pedagogies in computer science education. These guidelines are not intended as a fixed checklist but as evidence-informed considerations that educators, curriculum designers, and institutions can adapt to their specific contexts.

1. **Cultivate inclusive classroom climates as a foundational pedagogical condition.** Instructors should prioritize psychological safety, respectful discourse, and identity-affirming practices from the outset of computing courses. Explicit norms that value questioning, collaboration, and diverse perspectives help counter exclusionary climates that disproportionately marginalize female learners.
2. **Align collaborative pedagogies with explicit equity goals.** Collaborative learning should be intentionally structured to address power dynamics within groups, including role assignment, accountability mechanisms, and reflective debriefing. Without such scaffolding, collaboration risks reproducing gendered participation patterns rather than disrupting them.
3. **Design curricula around relevance, representation, and social context.** Computing curricula should integrate socially meaningful problems, diverse role models, and interdisciplinary contexts that reflect the breadth of computing applications. Representation should be sustained and authentic, embedded across courses rather than confined to isolated examples or units.
4. **Adopt formative and flexible assessment practices that broaden definitions of competence.** Assessment strategies should emphasize learning as an iterative process through formative feedback, portfolios, project-based work, and reflective tasks. Reducing reliance on high-stakes, speed-oriented evaluations supports diverse demonstrations of competence and mitigates stereotype threat.
5. **Embed mentoring and support structures within institutional ecosystems.** Mentoring programs, learning communities, and cohort-based initiatives should be integrated into departmental and institutional structures rather than positioned as optional or peripheral supports. Access to mentors with shared or affirming identities can be particularly impactful for sustaining persistence and belonging.

6. **Interrogate hidden curricular and disciplinary norms.** Educators and institutions should critically examine implicit values embedded in computing education (e.g., individualism, competition, and notions of technical "purity") and consider how these norms shape participation and success. Making these assumptions visible is a necessary step toward pedagogical transformation.
7. **Approach gender inclusion as an ongoing, reflexive process rather than a one-time intervention.** The literature underscores that inclusive pedagogies require continuous reflection, evaluation, and adaptation. Institutions should support professional learning and reflective practice that enable educators to move beyond superficial adoption toward sustained cultural change.

Implications for Practice and Policy

The synthesis of the literature underscores that advancing gender equity in computer science education requires coordinated action across classroom practice, institutional leadership, and policy frameworks, in alignment with global commitments to sustainable development. For computer science educators and curriculum designers, the findings highlight the importance of embedding inclusive pedagogical principles (e.g., collaborative learning, identity-affirming curricula, formative assessment, and flexible learning pathways) into everyday teaching practices, directly supporting SDG 4 (Quality Education) by promoting equitable and inclusive learning opportunities. At the institutional level, leadership plays a critical role in sustaining these efforts through investments in faculty development, mentoring programs, and learning communities that foster inclusive teaching cultures and address structural barriers faced by female learners, thereby advancing SDG 5 (Gender Equality).

From a policy perspective, gender equity in computing education requires alignment between educational policy, workforce development strategies, and digital inclusion initiatives, ensuring that equity goals are reflected in curriculum standards, funding priorities, and accountability mechanisms that contribute to SDG 9 (Industry, Innovation, and Infrastructure). Collectively, these implications suggest that meaningful progress depends not only on pedagogical innovation but also on systemic commitment to rethinking how computing education is designed, supported, and governed to promote inclusive and sustainable technological futures.

Limitations of the Existing Literature

Despite the growing body of research on gender-inclusive pedagogies in computer science education, several notable limitations persist. Much of the literature is heavily Western-centric, with findings from North America and Europe dominating discourse, which limits the transferability of recommendations to diverse cultural, social, and institutional contexts. Additionally, intersectional perspectives remain underexplored, resulting in an incomplete understanding of the varied experiences and needs of female learners. Finally, a persistent gap exists between policy rhetoric and classroom practice, where institutional or governmental commitments to equity often fail to translate into meaningful pedagogical change, mentorship structures, or inclusive curricula at the course level. Collectively, these limitations highlight the need for research that is globally representative, intersectionally informed, and attentive to the translation of policy into actionable, context-sensitive strategies for equity in computing education.

Future Directions for Research and Innovation

Based on the synthesis and guidelines suggested, future research in gender-inclusive computer science education should prioritize qualitative and longitudinal studies that capture the nuanced experiences of female learners over time, moving beyond cross-sectional surveys to understand persistence, identity development, and the long-term impact of pedagogical interventions. There is a pressing need to incorporate intersectional perspectives and amplify voices from the Global South, where sociocultural, economic, and infrastructural factors shape unique barriers and opportunities for equity in computing. Co-designing curricula and learning environments with students themselves offers a promising avenue for creating responsive, contextually relevant pedagogies that reflect learners' needs and aspirations. Moreover, bridging education, industry, and policy through collaborative partnerships can ensure that equity-focused initiatives are reinforced across academic programs, workforce pipelines, and governmental frameworks, translating inclusive intentions into tangible outcomes. Collectively, these directions point toward a research agenda that is participatory, globally aware, and capable of informing systemic innovation in computing education.

CONCLUSION

This chapter underscores that advancing gender equity in computer science education demands sustained pedagogical, curricular, and institutional transformation that foregrounds inclusion, representation, and learner agency. Across the reviewed literature, consistent evidence highlights the importance of inclusive classroom climates, collaborative and socially oriented pedagogies, identity-affirming curricula, flexible and formative assessment practices, and robust mentorship and support structures in fostering female learners' engagement, persistence, and sense of belonging in computing education. Responding to the gaps identified at the outset of this chapter, this chapter (1) systematically identified and categorized gender-inclusive pedagogical strategies reported across empirical, theoretical, and policy-oriented literature; (2) examined how these strategies address sociocultural, instructional, and institutional barriers shaping female learners' experiences in computing education; and (3) synthesized cross-cutting patterns, tensions, and design principles that inform actionable guidance for educators, institutions, and policymakers.

At the same time, the review reveals persistent limitations in the field. Overreliance on Western contexts, limited intersectional analyses, and recurring gaps between policy intentions and classroom-level enactment continue to constrain progress toward equitable computing education. These shortcomings point to the need for more globally representative, context-sensitive, and participatory research designs that meaningfully engage learners and educators as co-constructors of inclusive practice. Importantly, the chapter situates gender equity within the broader context of the contemporary expansion of artificial intelligence (AI) across education and the computing workforce. As AI increasingly shapes learning environments, assessment practices, and professional pathways, its role in reproducing or mitigating gender bias must be critically examined. Ethical and effective integration of AI in education and subsequent work-life contexts requires heightened awareness of bias embedded in training data, algorithmic design, and large language models, alongside deliberate efforts to counteract these inequities through inclusive pedagogical and institutional strategies. Without such critical engagement, emerging technologies risk reinforcing the very disparities that gender-inclusive education seeks to address.

Collectively, the findings reaffirm that pedagogy functions as a central lever for change, but only when aligned with institutional commitment and policy coherence. Advancing gender equity in computer science education is not the result of isolated interventions but of systemic efforts that integrate teaching practices, curriculum design, assessment, mentorship, and governance. Fostering inclusive futures in computing therefore requires sustained, reflexive, and equity-driven approaches that ensure technology is both produced and shaped by a diverse and socially responsive community of learners.

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KEY TERMS AND DEFINITIONS

Gender-Inclusive Pedagogy.: Teaching approaches, curriculum designs, and learning environments intentionally structured to promote equitable participation, representation, and success of learners across all genders, particularly addressing barriers faced by women in computing education.

Inclusive Curriculum Design.: The intentional integration of diverse perspectives, real-world relevance, and representative role models into course content and learning activities to support equitable participation and identity affirmation.

Mentorship and Support Structures.: Formal or informal relationships, learning communities, and institutional initiatives that provide guidance, role modeling, and relational support to enhance learners' academic, professional, and psychosocial outcomes.

Sense of Belonging.: The psychological experience of acceptance, inclusion, and recognition within a learning environment, which positively influences motivation, engagement, and persistence in computing programs.

Technofeminism.: A theoretical perspective that examines how technology and technological practices are socially constructed, gendered, and influenced by power dynamics, emphasizing the role of pedagogy and institutional practices in either reproducing or challenging gender inequities in technology fields.