Increasing gender diversity in Computer Science

A Systematic Literature Review of Interventions in Primary and Secondary Education

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Abstract

This paper covers a systematic literature review of documented interventions aimed at increasing gender diversity in the computer science field, focusing on primary and secondary education. Despite historical contributions by women in computing, gender stereotypes and misconceptions continue to persist, resulting in significant underrepresentation of females in this domain. Using the SALSA framework, the study builds an analysis of various educational interventions, such as camps, workshops, and hands-on activities, that successfully enhanced female participation in computer science. Key strategies identified include innovative teaching and instruction methods through the use of mentorship and female role models. The review highlights a positive impact on participating girls' self-esteem and community belonging that increases the rates of interest in computer science. The findings provide a comprehensive view of the successful approaches, suggesting that targeted educational practices can effectively mitigate gender disparities. Therefore, the computer science field continuously needs effort to create an inclusive environment for female primary and secondary school students.

Keywords: gender diversity, computer science, primary education, secondary education, educational interventions, systematic literature review, gender stereotypes, female participation, education, mentorship, role models, self-esteem, hands-on activities, camps, workshops.

1 Introduction

Since the times of ancient Greeks, education and schools were created and developed for male scholars [1]. This statement created a stereotype in both the education and scientific fields. What is not pushed into the light is the fact that all genders played a pivotal role in both education and research throughout history, dating back to Peseshet (cca. 2500 BCE), who was the first documented female physician [2] or even, for the computer science field, the first documented programmer, Ada Lovelace, being a woman [3]. This exclusion of females in the academic and research field can be seen in multiple areas of work even in the current days, especially in the ICT (Information and Communication Technology) field [4].

In Information and Communication Technology (ICT), women constitute only 17% of ICT specialists within the European Union [4], underscoring a significant gender disparity that extends into the academic sector. The same situation persists with Women in the United States, where they represent a mere 19% of the Computer Science graduates as of 2017 [5]. These statistics highlight the continuation of gender imbalances from education to the professional sphere, particularly in technical fields such as Computer Science. The persistent underrepresentation in CS demands a closer examination of educational strategies and interventions that can attract more women into this field, starting from the fundamental levels of education. This background establishes a place where we can tackle and understand the origin and motives of those misconceptions and stereotypes ending up in *Increasing gender diversity in Computer Science*.

Current research investigates ways to address this discrepancy and increase female interest in Computer Science from early steps in the educational life [6–18]. While this research reviews different strategies, it is critical to consolidate and evaluate these approaches to understand their effectiveness and usefulness. Moreover, it is crucial to understand whether the direction of those practices is beneficial, harmful, or ineffective regarding the outgoing stereotypes encountered. This research aims to address the gap by systematically reviewing documented strategies that have aimed to increase interest in Computer Science among primary and secondary school girls. This investigation's core question is: "*What practices have been documented to increase the interest in Computer Science of primary and secondary school girls?*"

We build the answer to the question in two steps. Firstly, conducting a **systematic literature review** on gender diversity in computer science, specifically targeting educational interventions for primary and secondary school girls. This review, is based on the **SALSA** framework (**S**earch, **A**ppraisa**L**, **S**ynthesis, and **A**nalysis) [19]. Afterward, presenting the **results and discussion** based on the synthesis and analysis from the methodology. The study breaks down the findings into multiple categories to be analyzed and put head-to-head in different contexts. In the results section, the paper dives into the most recurring strategies for implementing successful educational interventions toward reducing the gender gap in high school. Moreover, goals and targeted skills the students have to acquire are presented along with their underlying issues to understand better and tackle the issue for further research and educational implementations.

2 Background

The underrepresentation in Computer Science (CS) is a deep-rooted issue often recurring at educational and professional levels. Despite increasing societal awareness and strategic interventions to close the gender gap, progress remains slow. Historically, significant contributions of women, such as those by Ada Lovelace [3], who conceptualized early computing principles, even being considered the "first programmer", have often been unrecognized. This historical negligence contributes to the prevailing gender stereotypes in Computer Science, such as that it is a male-exclusive and unsocial field. Settling those stereotypes affects the sense of belonging and a significant lack of interest from females towards STEM [20]. Nevertheless, the outgoing curiosity arises around the matter of *why* and *how* at the current stage of the world, underrepresentation and lack of engagement from early ages for a specific gender is still present.

Women remain significantly underrepresented in CS across the European Union and the United States of America, accounting for only a minor percentage of ICT specialists [4] [21]. This disparity is visible in the early steps of life and is influenced by educational policies and cultural stereotypes that depict CS as a male-dominated field [21]. Such stereotypes are backed by media portrayals and societal expectations, which discourage young women from pursuing interests in technical fields.

The same disparity is also reflected in the academic field, with just 19% of female Computer Science graduates, as displayed in Figure 1, in the US in 2017 [5]. This statistic highlights the urgent need for interventions at the university level and during earlier educational stages, such as high school. Early interventions are crucial to reshaping perceptions and inspiring a broader demographic of students to engage in CS, fostering a more diverse and inclusive environment from a young age.

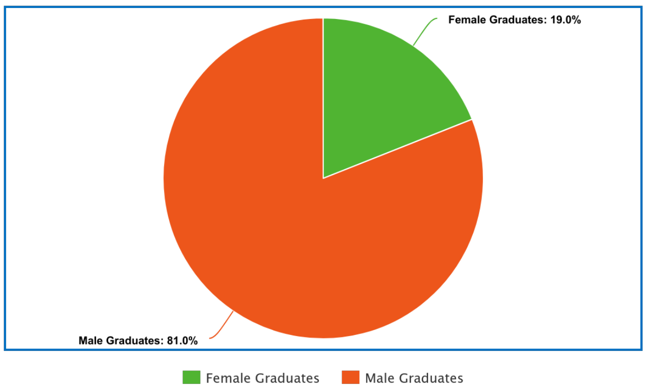

Figure 1: Graduation Statistics in Computer Science Based on Gender in the US for 2017

Introducing computing education at primary and secondary school levels is pivotal for altering perceptions and increasing female participation. Research shows that early programming education can influence career orientation and break down gender stereotypes [22]. Educational strategies incorporating gender-sensitive teaching methods and inclusive content can significantly impact girls' perceptions and interests in CS.

The societal and cultural dimensions play a critical role in shaping the career choices of young women. Addressing these stereotypes requires concerted efforts within educational systems, through media and community, to promote diverse and inclusive representations of CS professionals [23].

Several strategies have been implemented to enhance female participation in CS, from policy interventions to base educational programs providing mentorship and role modeling. Programs that focus on creating supportive community networks, offering scholarships, and establishing mentorship opportunities with female role models in CS have shown promise in increasing the participation and retention of women in CS [23]. Additionally, educational interventions that start at a young age and continue through university levels are crucial for maintaining interest and improving female students' self-efficacy in CS.

Understanding the historical context, addressing current challenges, and implementing targeted educational and societal interventions are essential for fostering a more inclusive and diverse CS community.

3 Method

This study systematically reviews the literature to identify documented practices that increase the interest of primary- and secondary-school girls in Computer Science. The review adheres to the guidelines presented by Kitchenham and Charters [24], which endorse a structured approach to conducting literature reviews.

The **SALSA** framework, as outlined by Grant and Booth [19], was employed due to its comprehensive nature in handling various review types. This framework encompasses four main components: **S**earch, **A**ppraisa**L**, **S**ynthesis, and **A**nalysis, which are systematically applied to ensure the thoroughness and reliability of the review.

The structure of this section is as follows: *Subsection 3.1* outlines the search strategy, determining the databases accessed and the search terms employed along with the corresponding query used. *Subsection 3.2* enumerates the criteria for including or excluding papers, filtering only valuable and valid data to be further studied and included in this research. *Subsection 3.3* dives into synthesizing the collected data from the chosen studies, outlining, integrating, and evaluating this data to uncover trends and commonalities using encodings. *Subsection 3.4* describes the analytical process applied to the synthesized data and discusses the derivation of conclusions from the compiled data, bridging the study toward the results section.

3.1 Search

Four databases were initially selected based on permissions available from the Technical University of Delft: *ACM Digital Library*, *IEEExplore*, *Scopus*, and *Web of Science*. *Google Scholar* was also added to this list to further assist in exploring unpublished and additional resources. Furthermore, during the construction step for the corresponding query in the research, due to filtering limitations imposed by some databases, the usage was restricted only to the following three: *ACM Digital Library*, *Scopus*, and *Web of Science*.

- *ACM Digital Library* provides a vast collection of computing and information technology publications, making it crucial for accessing valuable research in Computer Science education.
- *Scopus* offers a broad and multidisciplinary range of peer-reviewed content, valuable for its extensive coverage of educational research and its impact on gender diversity.
- *Web of Science* is included for its interdisciplinary content and strong citation tracking capabilities, enabling a thorough review of influential studies across education and technology fields.

Following up, the search strategy was structured in three steps to ensure comprehensive coverage:

1. **Identifying Keyword Groups:** Keywords were organized into specific groups to cover various aspects of the research question:
    - **Group A (Gender-related terms):** This group includes terms related to gender identification and distinctions, focusing on women and girls.

- **Group B (Action and diversity-related terms):** This group contains verbs and nouns that describe actions aimed at increasing or modifying participation and interest and terms related to diversity and inclusion.
- **Group C (Field of study):** These terms specify the academic disciplines of focus, namely Computer Science and its related technological fields.
- **Group D (Educational level):** The keywords here are related to educational stages, focusing on primary- and secondary schools along with their equivalents and synonyms
- **Group E (Educational context):** This group includes terms that cover various aspects of educational settings and methods, ranging from teaching techniques to formal schooling contexts.

2. **Logical Structure of the Query:** The query was structured to ensure that all keywords are interconnected logically, focusing on studies that address gender and diversity in educational contexts within Computer Science:
   - Intersection of Gender and Action/Diversity Terms (**Group A** and **Group B**)
   - Inclusion of Specific Contexts (Addition of **Group C** and **Group D**)
   - Broad Coverage with Specific Connections (Enlisting the context with **Group E**)
3. **Executing the Query:** Finally, we create the final query by merging the previous steps, as displayed in Figure 2.

```
(gender* OR female* OR woman OR women OR girl* OR femini*)
AND
(increas* OR decreas* OR inclus* OR exclus* OR broad* OR
divers* OR restrict* OR variet* OR interest* OR attract* OR
appeal* OR involv* OR enchance OR engage* )
AND
("computer science" OR programming OR software OR "information
technology" OR comput* OR cyber* OR tech*)
AND
("primary school" OR "primary-school" OR "secondary-school" OR
"secondary school" OR high-school OR gymnasium OR "elementary
school" OR "elementary-school" OR "middle school" OR "middle-
school" OR "junior high" OR "junior-high" OR "K12" OR "K-12")
AND
(educat* OR teach* OR school* OR schol* OR cours* OR stud* OR
practic* OR train* OR tutor* OR learn* OR method*)
```

Figure 2: Final Query Formulation

After executing the respective query on the decided databases, we ended up with 66 recordings, from which 11 entries were from *ACM Digital Library*, 28 entries from *Scopus*, and 27 entries from *Web of Science*

3.2 AppraisaL

The upcoming step is the selection process of the papers according to the **PRISMA** (**P**referred **R**eporting **I**tems for **S**ystematic reviews and **M**eta-**A**nalyses statement), as it outlines a clear, systematic, and prosperous way of filtering the data [25]. This process includes three main steps: *Identification*, *Screening*, and *Eligibility*. For each step, a clear visualization is present in the flow diagram corresponding to Figure 3.

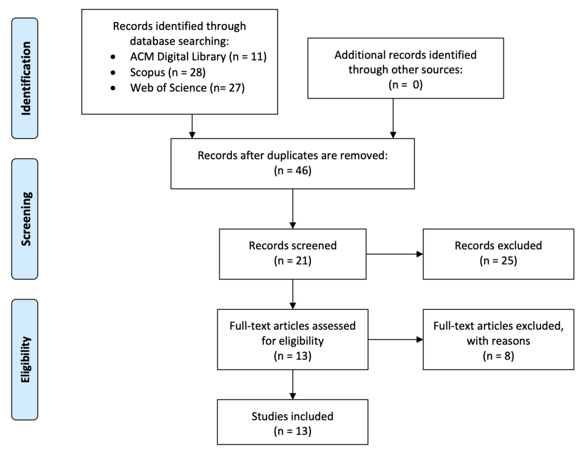

Figure 3: PRISMA Flow Diagram

The *Identification* step involves extracting the papers and eliminating duplicates. The extraction tools used are *Zotero*[1] and the *auto-export* function of the online databases. After this step, the number of papers is 46.

Furthermore, the *Screening* involves filtering the selected texts according to the following inclusion and exclusion criteria based on the abstract and title of the papers:

Inclusion Criteria:

- Papers written in English
- Papers from journal articles and conference proceedings to capture peer-reviewed studies and current discussions in the field.
- Papers focusing specifically on Computer Science education, ensuring relevance to gender diversity in these fields.

Exclusion Criteria:

- Non-English papers are excluded due to language constraints.
- Literature outside Computer Science, such as unrelated fields or broader educational studies without a clear focus on the targeted disciplines.
- Theoretical papers without empirical data or practical applications, as the review focuses on actionable and tested interventions.
- Papers that are written before 2005 to maintain a focus on contemporary research developments.

[1] Zotero — your personal research assistant, from https://www.zotero.org/

- Papers unrelated to addressing the reduction of the gender gap are excluded to maintain focus on pertinent research.

This first iteration of the papers results in the remaining 21 papers to review after applying the according criteria.

We finalize this process with the *Eligibility* step. Here, a comprehensive review of the methodology, discussion, and conclusion sections is crucial to ensure relevance according to the scope of the research. This step also ensures the validity of the inclusion and exclusion criteria applied to the papers through a second pass-through.

By the end of those steps, we end with 13 relevant papers [6–18] that will go towards the synthesis process.

3.3 Synthesis

With the resulting papers, a synthesis step follows to aid the information analysis. We adopt an encoding of information strategy as it supports both classification and collection of valuable data. The approach includes deductive and inductive encodings to analyze and categorize adequate findings.

Deductive Analysis: Classification of information derived from the Appraisal phase, focusing on the types of activities and their outcomes in gender diversity initiatives within education.

- *Type of Intervention:* Identifies the type of activity adopted during the intervention, such as a summer camp or a workshop.
- *Nature of Documentation:* Differentiates between reports of specific activities and broader analytical studies on the interventions.
- *Issue Addressed:* Specifies the main focus, such as combating underrepresentation or providing role models.
- *Skills Development:* Describes the specific skills targeted by the intervention, including social skills or algorithmic competencies.

Inductive Analysis: Identified emerging themes not initially anticipated, allowing for discovering new insights into effective practices.

3.4 Analysis

Analyzing the exported results along with the decided synthesis encodings will involve a two-step process: the papers will be classified based on the deductive encodings, followed by an in-depth analysis of each paper based on the different positions the respective paper takes regarding the encoding. This process will run parallel with exploring emerging and potential inductive encodings of the findings.

For the initial step, we analyze the results based on the initial deductive encodings. The papers are parsed once for a broad classification into each group of encodings initially identified. Therefore, after the first iteration of analyzing the data, we categorized the following papers into the upcoming groups based on each category, as displayed in Table 1.

Furthermore, the research continues with the second step, which consists of an in-depth analysis of each paper to confirm the data further and conduct an analysis parallel with note-taking and the deductive steps to find unseen or unpredictable similarities between them.

An inductive encoding that arose during our analysis pertains to the *recruitment methods used in these interventions*. This theme emerged repeatedly across various studies, indicating variations in recruitment strategies and their impacts on the effectiveness and validity of the interventions. Similarly, another differentiation between papers occurs: whether the documented intervention is *exclusive to female participants*. This separation can affect the outcomes and generalizability of the interventions. Exclusive programs may provide a secure space for female students but risk reinforcing gender segregation. In contrast, mixed-gender programs can foster inclusivity and collaboration but may not address specific gender-related challenges as effectively.

4 Results

The systematic literature review results are presented in this section in a structured manner, following the deductive and inductive encodings decided on from the appraisal step of the review. The findings are detailed based on each category, reflecting on the corresponding findings in order to propose better reiterations, further implementations, or integrations of those activities in the current-day field of computing.

4.1 Type of intervention

To better understand which intervention proves to be effective and a good match to be reproduced, the most common intervention practices are discussed along with their iterations: Camps, Workshops, Surveys, and Online interventions.

The most common intervention practice to increase gender diversity is **camps**, with examples of six studies detailing their implementation and outcomes. These camps, such as those documented by Al-Duwis et al. [10] and Kumar and Ott [14], focus on engaging female students through immersive, hands-on activities designed to foster interest in computer science. Those prove a great interest and success rate due to the connection the students can make to the staff along with the possibility of more in-depth analysis of the decided curriculum as pointed out by Gannod et al. "experience with the camp continues to be positive, and the instructors, counselors, mentors, and campers agree that the effort and outcomes are worthwhile." [11]

Workshops are another prevalent intervention identified in six studies that provide short-term, intensive training sessions to build specific skills and knowledge. These workshops, highlighted in studies like Bonner and Dorneich [9] and Gutica [15], often target girls to boost their confidence and abilities in computing. For another example, the study conducted by DeLyser and Williams [17] aimed at mitigating the gender gap through revised recruitment strategies of the Academy for Software Engineering (AFSE) in New York City. This "strategy is to hold Girls Only open houses" [17] where young girls are mentored and walked through state-of-the-art technologies and staff of the project demonstrate some of the "projects they complete in the school, partner companies who speak about how technology is being used to change the world, and partner organizations such as Girls Who Code,

Category	Subcategory	Papers Identified
Type of Intervention	Camp	[8, 10–14]
	Workshops	[9, 10, 14, 15, 17, 18]
	Online Interventions	[6, 7, 13]
Nature of Documentation	Reports of Specific Activities	[6–15, 17, 18]
	Broader Analytical Studies	[13, 15, 16, 18]
Issue Addressed	Underrepresentation	[6–18]
	Lack of Role-Models	[9, 13–15, 17]
	School and curriculum-based Issues	[7, 9–11, 13, 14, 16–18]
Skills Development	Social and Community Skills	[7–9, 11, 13, 14, 17]
	Enhancing Self-Esteem	[6–8, 11, 13]
	Algorithmic Competencies	[10–12, 14, 15, 18]

Table 1: Categorization of Interventions and Documentation

Black Girls Code, and others that will engage with the girls" [17]

Lastly, **online interventions**, featured in three studies, leverage digital platforms to reach a broader audience, providing flexible and scalable solutions for promoting gender diversity in computer science. These interventions, part of a broader on-site activity, highlight the potential of online methods to engage students in meaningful ways despite geographical and logistical constraints. Those practices ensure a continuous connection and access to any project, implying a considerable benefit as mentioned by Pinkard et al. "in order to immerse the girls in the story and provide additional opportunities to interact with one another outside the face-to-face environment" [7]. On the other hand, even if complete freedom and power of connection across the globe open up uncountable opportunities, the social factor is lost along the digital connection established and as pointed out by Bonner and Dorneich [9], Gutica [15], and Barksdale [18] the social connection and collaboration are crucial in computing. Due to the settled misconception, this connection has to be approached on-site first, leading to a decreased number of online practices, as mitigating the gender gap tends to be more effective in the offline media.

4.2 Nature of documentation

Reports of specific activities constitute most of the reviewed papers, with twelve studies detailing interventions to increase female participation in computer science. These reports focus on practical implementations and their immediate impacts, such as hands-on activities, camps, and workshops, providing insights into the direct effects of short-lived interventions and what actions are needed. These studies help understand the short-term issues and how to face and mitigate them on the go, establishing an environment suitable for further developments. These interventions, which appear to be the most efficient, provide recent results related to the described activities but do not allow for a thorough understanding of the underlying issues in the industry.

On the other hand, **broader analytical studies**, represented by four papers, some of them intersecting with the previous category, offer a more comprehensive examination of gender diversity initiatives, often assessing the long-term outcomes and strategies influencing these programs. These studies and similar research offer a more precise overview of the techniques employed, offering valuable insights for long-term educational practices and implementations towards a more all-round field.

4.3 Issue Addressed

Several critical issues related to gender diversity in computing and computer science are present in the studied documents. All thirteen of the studies included in the review are facing the **underrepresentation** of women that is present in the field, pointing on different levels how this affects and broadens up the gap in the field [6–18]. The **lack of role models** is another critical issue, identified in five studies. These studies, such as those by Pinkard et al. [7] Barksdale et al. [18] and Gutica [15] tackle the issue by providing the opportunity of mentorship and guidance from women already involved in the field, accessing their knowledge-base and experience but at the same time being able to relate with them and projecting a future-self into those persons.

Additionally, nine studies mention and tackle **school and curriculum-based** issues, analyzing how changes in the educational environment and curriculum can influence girls' engagement and performance in computer science. The text from Olivieri [16] addresses the issue of the high-school environments not allowing girls even to try to discover the field of computing, being intimidated, and the absence of a supportive learning environment for girls, thus enlarging the gap. After the study, the researcher proposes that the girls "be educated in both the content of computer science and in the understanding of what computer science is" [16] to lower the anxiety and retention towards computers significantly. Similarly, the study conducted by Al-Duwis et al. [10] takes the opportunity to enhance the existing curriculum with hands-on and interactive activities, complementing the national education curriculum in Saudi Arabia. Another notable approach is the one done by DeLyser and Williams [17] where the problem addressed is how the curriculum display presents to the female audience instead of the content. This study details changes to the presentation of the academic contents in an inclusive environment, highlighting that their curriculum is inclusive and supportive for all types of students.

4.4 Skills Development

Each case study reviewed tackled a different set of *soft* and *hard skills* to effectively address the lack of interest and attractiveness of Computer Science among young female students.

Social and community skills were a primary focus in seven reviewed studies. These interventions often involved group activities and collaborative projects designed to foster community sense and teamwork among participants. For instance, Bonner and Dorneich [9] used game-based learning to promote social interactions and community building among middle school girls. Similarly, Fey et al. [8] pinpointed the live-action role-playing (LARP) camps create a social and collaborative environment that encourages middle school girls to engage with computer science: "helped them form a cohesive community and supported an increased interest in learning computational skills." [8] These studies underscore the importance of creating a supportive peer network to help girls feel more connected and motivated in their pursuit of computer science.

Enhancing self-esteem for girls represents another vital area highlighted by five studies. Interventions in this category aimed to build confidence and self-efficacy in female students, helping them overcome stereotypes and self-doubt. Phelps [6] statistically demonstrated that hands-on activities could significantly boost middle school girls' spatial skills and self-confidence, making them more likely to consider careers in technology. Self-esteem and trust are social properties consistently encountered across the study, along with the feeling of accomplishment after a series of interactions with the newly discovered technologies or concepts. For instance, Vachovsky et al. [13] point out that their program helped students develop self-trust and confidence after they managed to understand and work with AI concepts: "increase students' understanding of the technical methods used in AI as well as their excitement towards research in the field [...] left knowing concrete, specific technical methods that can solve the problems they are passionate about" [13]

Six studies have found that **developing algorithmic competencies** is essential to improving girls' understanding and application of fundamental computing concepts. Understanding algorithmics' essential concepts and principles represents the initial bridge to broad access to information across the computing domain, enhances technology perspectives, and marks the minimal entry point into such fields. In their study, Sowells et al. [12] described the importance of algorithmic thinking in allowing unfamiliar participants to opt for taking into consideration technical fields. Similarly, the papers from Gutica [15] and Gannod et al. [11] directly relate those skills with a consistent boost in confidence, resulting in a more energetic and enjoyable approach. Focusing activities on this skill ensures an open opportunity for female students to explore and discover areas of computer science without any supplementary information needed to ensure a worry-free start.

4.5 Enrollment stragtegies

The analysis of the reviewed studies also revealed emerging themes related to enrollment strategies used in interventions. Different approaches to selecting participants for camps, workshops, and other programs can question the effectiveness of these interventions.

Some studies employed **random enrollment** methods to select participants, aiming to provide equal opportunities for all interested students. For example, Al-Duwis et al. [10] randomly selected high school girls for their summer camp, ensuring a diverse mix of participants without bias towards specific skill levels.

Other studies focused on **skills-based enrollment**, selecting participants based on their demonstrated abilities or interests in computer science. Kumar and Ott [14] recruited talented high school girls who had shown a strong interest and aptitude in STEM fields for their summer program, ensuring that the participants were already put in theme or had a drive towards computer science, facilitating the initial steps by themselves.

A notable approach was the **category-based enrollment** strategy, targeting students from specific socio-economic backgrounds. Sowells et al. [12] designed a summer boot camp specifically for low-income high school girls, aiming to increase their interest in technology careers. This enrollment method ensures an opportunity for this category of female students who may not have access to the resources needed to pursue this field.

4.6 Gender Exclusivity Participation

Another commonality that emerged from the study was the gender exclusivity of participants. Out of the 13 studies, ten documented female-only participants while, on the other hand, just three interventions acted with a hybrid approach, with both male and female participants

Exclusive participation for girls was the standard approach, with ten studies adopting this model [6–8, 10–14, 16, 18]. The primary reason for this choice was to create a supportive and confidence-building environment tailored specifically for girls. This environment proved to be a solution for enhancing the community belonging sense, as presented by Fey et al. [8]. Those interventions mitigate the impact of gender stereotypes, allowing the female participants to discover new role models. By excluding boys, these programs sought to reduce the intimidation and anxiety that girls might feel in a male-dominated setting.

In contrast, three studies [9, 15, 17] employed **mixed-gender participation**. These studies focused on inclusive strategies that engage both girls and boys, promoting gender diversity and collaboration. The motivation behind this approach was to encourage a more integrated learning environment where both genders can learn from each other and work together. Mixed-gender programs aimed to challenge and change gender stereotypes by demonstrating that computer science is a field for everyone, regardless of gender [15]. Additionally, these interventions aimed to prepare students for real-world scenarios where they would collaborate with people of different genders and backgrounds.

5 Discussion

The findings from our systematic literature review indicate that all the documented interventions aimed at increasing gender diversity in computer science have been successful. These interventions, including summer camps, workshops, and online platforms, consistently and positively impact girls' interest and participation in computer science. This consistency suggests that the current strategies are practical and valuable for educational practitioners and policymakers aiming to reduce the gender gap in this field. As recommended by the conclusions sections in each one of the studied papers, more significant interventions are needed from educational institutes. Given these successes, further iterations and adaptations of those interventions must continue adopting and supporting the concepts studied and displayed in this paper. Schools and educational programs should consider integrating these proven strategies into curricula and extracurricular offerings. By doing so, they can create more inclusive and supportive environments that encourage female students to explore and excel in computer science.

However, the consistent 100% success rate reported in the extracted papers raises concerns about potential publication bias. This bias may need to be clarified for the less successful aspects of these interventions, failing to reveal the challenges and difficulties encountered during implementation. Documenting failures is crucial for understanding mistakes, identifying where they occurred, and developing strategies to overcome them. With more documentation added to the one discussed, we can recognize essential lessons that could enhance the effectiveness of future interventions.

While those interventions have proven beneficial in increasing interest in computer science and boosting female students' confidence in the field, they can also accidentally reinforce stereotypes if not carefully implemented and tuned. These programs may be perceived as special accommodations for girls, perpetuating the notion that computer science is a field primarily for males. Additionally, if an educational curriculum is not naturally inclusive, further additions or interventions may seem synthetic, establishing a misguided concept rather than addressing genuine needs.

From the design steps, an educational curriculum must include broader perspectives and contributions toward addressing social disparities, such as gender inclusivity. A lack of inclusivity risks portraying a narrow view of educational curriculums. Therefore, educators and policymakers must balance promoting female participation with strategies that integrate both genders, fostering a collaborative and inclusive learning environment that reflects the real-world dynamics in computer science.

Moreover, ongoing research is essential to evaluate and refine these interventions to suit diverse educational contexts. Continuous assessment and adaptation will ensure these programs remain relevant and practical, addressing new challenges in promoting gender diversity in computer science. This ongoing effort will help maintain the positive momentum achieved and support the development of even more inclusive and supportive educational environments for female students.

6 Limitations and Responsible Research

6.1 Limitations

This research has explored practices to increase gender diversity in Computer Science, yet it is not without its limitations. Despite efforts to conduct a thorough and unbiased systematic literature review, the scope of the literature has constraints in the dependence on specific databases, which may have overlooked relevant studies not included in this set. The linguistic limitation to English-language papers excluded significant research conducted in other languages, potentially biasing the insights toward Anglophone perspectives. Additionally, the methodological limitations of the selected studies, such as small sample sizes or short-term study durations, affect the generalizability of the findings. Another limitation of this research is the lack of exploratory research using *Google Scholar*[2] due to its limited filtering options, which might have restricted the breadth of studies reviewed. This limitation underscores the importance of multiple search platforms to capture a comprehensive array of relevant literature. Moreover, as a male researcher, the potential for unconscious biases influencing the analysis of gender-related issues cannot be ignored. While we made continuous efforts to avoid and mitigate any perspective biases during the research, the personal context of the study may subtly shape aspects of the study, emphasizing the importance of diverse perspectives in research on gender diversity.

6.2 Responsible Research:

This study upholds the principles of responsible research with a commitment to reproducibility, ethical integrity, and objectivity. We chose systematic literature review methods for their structured approach, which ensures reproducible search strategies. We meticulously documented every step, from database search to data analysis, to ensure transparency and enable independent verification of the findings. We also methodically analyzed all data to counteract confirmation bias and ensure a balanced interpretation of the findings. Acknowledging limitations is crucial in pinpointing the weak points of the study, along with the biases that could influence the interpretation of gender-related data. We took measures to critically and objectively analyze the findings, actively seeking studies challenging pre-existing notions. Additionally, we utilized *Grammarly*[3] to ensure accuracy in spelling and grammar throughout the paper, enhancing its overall clarity and professionalism. We recommend that the research community conduct additional systematic reviews as more peer-reviewed articles become available to ensure the conclusions are founded on the most robust and reliable evidence.

7 Conclusions

The paper provides a comprehensive systematic literature review of various documented interventions aimed at increasing gender diversity in computer science, specifically within

[2]Google Scholar — A freely accessible web search engine for scholarly literature, from https://scholar.google.com/

[3]Grammarly — Writing assistance and grammar checker, from https://www.grammarly.com/

primary and secondary education. The analysis utilized the SALSA framework to identify and evaluate effective strategies, including camps, workshops, and online platforms.

Key findings highlight the importance of restructured teaching methods, mentorship, and female role models in fostering a supportive and inclusive environment. Implementing those recommended methodologies boosts girls' self-esteem and perception of the field, leading to a consistent filling of the gender disparity gap.

However, the research also reveals potential areas for improvement and further investigation. The consistency in reported success across studies suggests a possible publication bias, indicating the need for more transparent documentation of challenges and less successful outcomes.

Ongoing efforts to adapt and implement these findings in diverse educational contexts will be crucial in maintaining momentum toward gender diversity in computer science. By continuously assessing and refining these strategies, educators and policymakers can ensure that interventions remain practical and relevant, ultimately contributing to a more inclusive and equitable field.

As we reflect on women's historical and contemporary contributions to computing, it is evident that targeted educational practices can significantly mitigate gender disparities. The persistent efforts to create inclusive environments for female students in primary and secondary education are essential for fostering a diverse and innovative future in computer science.

As we conclude this study and paper, after reviewing and progressing through the analyzed papers, I shall ask you, the reader, one question: *Should you still question yourself if education and school were created and developed only for male scholars?*

A Glossary

In this section, we explain key terms relevant to our research to provide clarity and context for readers.

- **Gender**: In the context of this research, the term "gender" refers specifically to a bi-gender framework encompassing both male and female genders. This scope allows for a focused analysis of the disparities and interventions related to gender diversity in computer science.
- **Stereotype**: A widely held but fixed and oversimplified image or idea of a particular type of person or thing. It is often based on assumptions and can lead to biased perceptions and discrimination.
- **Gender Diversity and Gap**: The equitable representation and inclusion of different genders in various fields, particularly in areas historically dominated by one gender, such as the computing field. This term also encompasses the disparities in outcomes, opportunities, attitudes, and experiences between genders, often observed in professional, educational, and social contexts.
- **Educational Interventions**: Strategies and programs implemented within educational systems to address specific issues, such as increasing female participation in computer science or improving academic performance.

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