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Role Models as an Intervention for Gender Diversity in Computing Education

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Abstract. ***Context:*** The lack of gender diversity has been a persistent challenge for computing fields for decades. Both in education and in the workforce, men are in a significant majority, which poses a threat not only to social fairness and gender equality, but also to the quality and inclusiveness of new technology produced by computing teams. Studies suggest that role models can be a helpful intervention for improved gender diversity and equality, but little research has been done to explore the concept more in-depth and specifically within the computing education context.
Objective: The research objective of this paper is to explore the concept of role models in relation to gender inclusion in computing education.
Method: The method used to answer the research questions is a systematic literature review.
Results: The SLR included 16 primary papers published between 2015 and 2023. The results, presenting what current literature exists regarding the relevance of role models in computing education, reveal a lack of focus on non-US-based contexts and on the retention, not only the recruitment, of women students in computing. Most of the papers found focused on K-12 education. The paper also provides insight into who is considered to be a role model in the context of computing education, and why they are considered role models.
Conclusion: The results indicated a scarcity of global research on the usefulness of role models for gender diversity within computing education, which calls for further explorations. Teachers and older students are the most commonly identified role models, and they work as role models by breaking down stereotypes and other barriers faced by girls in computing, but certain features must be present in order for them to fulfill such roles. Relatability in gender, age, and passion were identified as significant attributes of role models, which can be useful to keep in mind when designing DEI interventions involving role models in CS education.

Keywords: Computing Education · Diversity, Equity, and Inclusion · Role Models · Gender · Systematic Literature Review.

1 Introduction

In recent years, computing has been a strongly male-dominated field, both in the industry and academia [1], [2]. Computing being such a homogeneous field

threatens the production of inclusive and unbiased technology. Leavy [3] emphasizes the need for more gender-diverse teams in order to avoid bias in the development of artificial intelligence. In software development it is also crucial to aim for diversity in the development teams, as men and women have been found to use software in different ways and thus have different needs [4], [5]. Gender balance in computing education benefits all genders, as pointed out by Lagesen's *et al.* research: not only women's, but men's drop-out rates were reduced with an increased gender balance [6].

Nevertheless, there are several challenges that hinder both the recruitment and retention of women in computing, and stereotypes play a crucial role. The main challenges for recruitment are societal stereotypes about what types of people want to work in the computing field [7]: they are often depicted as nerdy, young men, with glasses and tech equipment [8], [9]. Research shows that role models might be able to counteract this barrier, by being examples of people breaking the stereotype [10]. However, several gaps have been identified in the research on role models and their impact [10], [11], something this study seeks to address.

In addition to recruiting women, keeping them in the field is also a challenge due to high dropout rates [6]. To overcome negative stereotypes [1], especially about women's abilities in the field [7], [12], role models, ie. people who have made it, can help by exemplifying that women can also be successful in the field of computing and showing they belong.

Research done by Drury [13] suggests that having a high perceived similarity to role models is a key element for success in using them as a means of both recruitment and retention. To successfully use role models as an intervention for improved gender diversity in computing, there needs to be a better understanding of who function as role models and what characteristics they have that make them role models.

2 Background

2.1 Gender Diversity in Computing Education

Women are, and have been for years, significantly underrepresented in computing fields [1], [7]. This lack of gender diversity poses several issues in the field of computing and society as a whole. The lack of diversity in development teams, both software development and other technologies such as AI [5], can negatively impact the communication within teams, as well as the quality of the product [14]. Due to these identified problems caused by the lack of gender diversity, a significant amount of research has been done to identify reasons for the lack of women in computing. It is commonly found in research that both a low sense of belonging and stereotype threat are crucial causes for the low number of women in computing [1], [7], [15].

Stereotypes pose a threat both to recruitment and retention. For instance, the stereotypes about what kind of people work in computing, as displayed by

media and pop culture, have been shown to be a reason for girls not enrolling in computing classes and degrees [7]. Therefore, such stereotypes about the field are at the core of recruitment issues in computing. Additionally, women that do enter computing, have to continue to overcome obstacles. The belief that women are less skilled for tasks related to the field has been pointed out as a key reason for why women abandon the field, either during their studies or in the workforce [1], [15].

Women have been constituting less than 20% of computing majors, which reveals persistent issues in computing education [6]. It is not only attracting women to the field that is crucial, but also keeping them. Female students in male-dominated academic areas are more likely to think about leaving their field due to their minority status [1]. Research done at Stanford University found that women, and other minorities, are more likely to drop out of SEM degrees[1] [16].

Another, related challenge women face in computing education is low self-efficacy. Computing is seen as a technical, nerdy, and isolated field of study, which is "unfeminine" [7]. This causes that female students have less self-confidence in computing, decreasing their motivation [17] and increasing their fear of negative stereotypes [17].

2.2 Role Models in Computing Education

Role models have been suggested by research to help solve a number of different gender diversity-related obstacles in computing. *A role model* is a frequently used term, defined by Gibson [11, p. 136] as "a cognitive construction based on the attributes of people in social roles an individual perceives to be similar to him or herself to some extent and desires to increase perceived similarity by emulating those attributes." In other words, a role model is someone one feels somewhat similar to and wishes to be more like.

Role models have been shown to help increase female students' confidence [17], improve their sense of belonging [18], and counter stereotypes about both women's computing abilities [19] and about who can work in the field [10].

There is, however, less research on the application of role models as an intervention for improved gender diversity, and what attributes these role models should have. Some studies have found that female students are more inspired by same-gender role models than their male peers [12]. Nevertheless, Drury *et al.* [13] found that the gender of the role model matters more in the retention of female students, and not as much in recruitment. Role models are also considered low cost [11], given that individuals chose their own role models, making them easier to implement than e.g. mentoring programs, which is another popular intervention for gender balance in computer science [20].

[1] SEM is an abbreviation of Science, Engineering and Math and is the older "sibling" of STEM as we know it today

3 Methods

The purpose of this study is to find and evaluate existing research on role models as an intervention to have more female students in computer science education, as well as to find gaps in the research. Because of this, the chosen research method is a systematic literature review (SLR). An SLR is chosen instead of a systematic mapping study because in-depth information from the results of the papers is required to answer the research questions (RQs).

The study followed the guidelines by Kitchenham [21] and Keele *et al.* [22]. The following four steps were conducted: Identification of research, selection of primary studies, data extraction, and data synthesis.

Step 1: Identification of research
The first step was to establish the research objective. Once this was done, research questions were created to help break down the objective into manageable pieces. Using the RQs as a guide, a protocol for the SLR was created, including exclusion and inclusion criteria, as well as quality assessment criteria. Lastly, a search query was selected based on keywords from the RQs.

Step 2: Selection of primary studies
The selection process of the primary studies was done iteratively. In the first round we excluded papers based on the inclusion and exclusion criteria, looking at the title and abstract of the papers. In the next round, the papers were read more carefully and assessed more thoroughly using the quality assessment criteria as well.

Step 3: Data extraction and monitoring
In accordance with Kitchenham [21], a data extraction form was created as part of the protocol to properly document the studies and avoid bias in the data extraction process.

Step 4: Data synthesis
Descriptive synthesis and qualitative analysis were used to identify themes from the studies, as well as to determine if the themes were homogeneous or heterogeneous, and how they relate to the RQs [21], [22].

3.1 Research Questions

This SLR aims to summarize existing knowledge and research contributing to the impact of role models on gender diversity in computing. Based on this research objective, the following research questions have been set:

RQ1: What recent research exists that explores the impact of role models on computing students?
Motivation To collect existing studies and knowledge related to the use and

impact of role models in computing education.

RQ2: Who functions as a role model in computing education?
Motivation To find out what types or groups of people typically function as role models and what attributes are important.

Table 1. Search Query

Database	Search query	Hits
Scopus	TITLE-ABS-KEY (("Role Model") AND ("Computer Science" OR "Computing" OR "Informatics") AND ("Gender" OR "Wom*n" OR "Girl*")) AND PUBYEAR > 2013	136

3.2 Data Sources and Search Strategy

Scopus[2], an electronic database containing peer-reviewed studies and published books, was used to search for relevant papers. In line with Keele's [22] recommendations on generating a search strategy, the search string was developed iteratively to find the best selection of papers related to the RQs and included trial searches to test different keywords from the RQs. The final search query, containing keywords from the RQs, is presented in table 1.

The query included limitations on publication year since the aim of the study was to find recent research, as defined in RQ1. It was decided that *recent* would be defined as having been published within the last 10 years.

Table 2. Selection Criteria

Inclusion Criteria	Exclusion Criteria
1. The paper addresses one of the RQs. 2. The paper has subject area computing. 3. The paper mentions role models in the abstract or as a keyword. 4. The study is done in the context of education.	1. The paper is not in English. 2. The paper is published before 2013. 3. The paper is duplicate work by the same author, presenting similar results.
Quality Criteria	
1. The study is empirical. 2. The study is available and complete. 3. The study comments on the effect role models has on girls' attitude towards computing. 4. The study is based on research. 5. The study has a clear aim. 6. The context of the study is clearly described. 7. There is proper use of English in the paper.	

[2] https://www.scopus.com/

3.3 Selection of Primary Studies

The final search string in Scopus resulted in 137 potential studies. These studies were exported to Zotero[3], a free tool that is useful for managing libraries of academic papers. In the first step of the study selection process, the inclusion and exclusion criteria presented in table 2 were applied to the title and abstract of the 136 studies in Zotero. After this step, 42 potential primary studies remained.

Next, the quality criteria presented in table 2 were applied along with the selection criteria to further filter potential papers. The quality criteria were used to ensure that included studies were proper empirical studies of high quality and not merely stating expert opinions, and further ensuring that they relate to at least one of the RQs. This step resulted in a final number of 16 primary studies.

4 Results

This section presents the results from the SLR about recent research on role models in computing education. From the initial 137 studies retrieved from the search query, a total of 16 primary studies[4] were left after exclusion and quality assessment (see Appendix A).

4.1 RQ1: What recent research exists that explores the impact of role models on computing students?

Publication Country The bar graph, color-coded by continent, in figure 1 presents the distribution of publication countries of the primary studies. When the studies are grouped by continent, North America has the highest representation with 7 studies, followed by Europe with 6 studies. Looking at countries individually, however, the US has twice as many publications as the countries with the second most publications: Switzerland and Australia. The US is responsible for 6 out of the 7 papers from North America. For Europe, half of the selected primary studies are from Switzerland. Also, with the exception of Turkey, all represented countries are from Western Europe, meaning that there is a lack of studies from the eastern parts of Europe.

We also find that several continents are missing completely from the collection of primary studies: Africa, South America, and Asia.[5] The countries and continents represented are all part of what is often referred to as the *Global North*, while there is no representation for *Global South*. The Global North and the Global South are terms used to distinguish different economies of the world, based on politics, technology, wealth, and demography [23]. The Global South is often labeled as less developed and more marginalized. Accordingly, the primary studies also show a lack of coverage of these areas.

[3] https://www.zotero.org/

[4] Throughout the paper, the 16 studies will be referred to as S (standing for study) and their number, ie. S01 ... S16.

[5] With only one exception, the studies themselves are conducted in the same country as the publishing country. The paper published in Turkey, S04, gathered data from 12 different countries in their study.

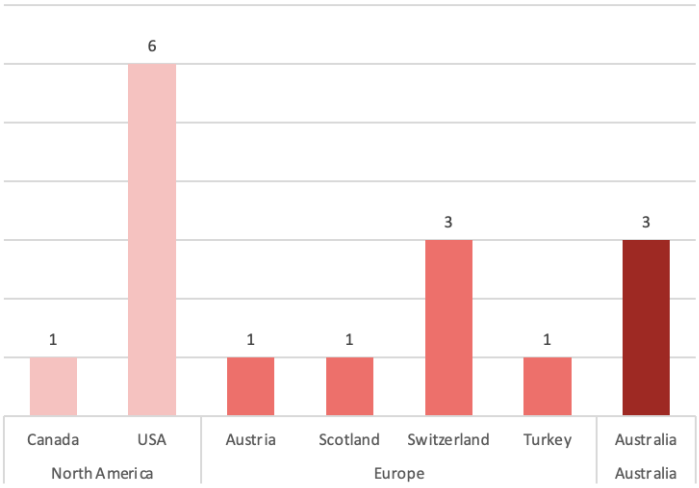

Fig. 1. Publication Country and Geographical Focus of Interventions

Recruitment vs Retention The distribution of interventions focusing on recruitment vs retention is displayed in the pie chart in figure 2A. 81% of the studies focus their efforts on increased recruitment. The two studies with a focus on retention, making up 13%, are S11 and S16. S11 is a case study evaluating an intervention program's ability to retain women in computing. The intervention program utilizes role models as part of their efforts. S16 is a case study of a remote mentoring program for girls in a CS class. As the sample was high school girls, this case could also be categorized as a recruiting effort to keep their interest and increase the chance that they pursue CS at university.

Education Level Regarding the education level of the participants in these interventions, three different categories were identified: K-12, higher education, and miscellaneous. K-12 includes education from kindergarten to year 12, at the end of high school; higher education describes university and college students; and the miscellaneous category is used for the two exceptions, S13 and S05. S13 made interviews with participants who were students, professors, and career professionals, while S05 explores teachers as role models by surveying their stereotypes and perceptions about computer scientists, which leaves the education level of students vague. The graph in figure 2B presents the distribution of the education level of the sample population used in the different studies. It is apparent that K-12 is by far the most explored level of the education pipeline. Only about a fourth of the selected primary studies explore role models for female computing students in higher education.

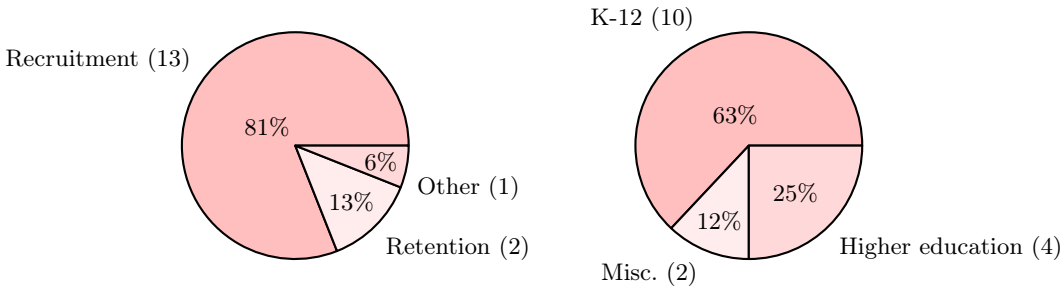

Fig. 2. (A) Recruitment vs Retention and (B) Education Level of Participants

4.2 RQ2: Who functions as a role model in computing education?

Teachers and university students are the most commonly identified group of people to function as role models for women in computing education. The graph in figure 3 presents the count for each mention of a group of people as role models. Note that the total number of mentions is greater than 16, the number of primary studies, because several papers identify more than one group of people as role models.

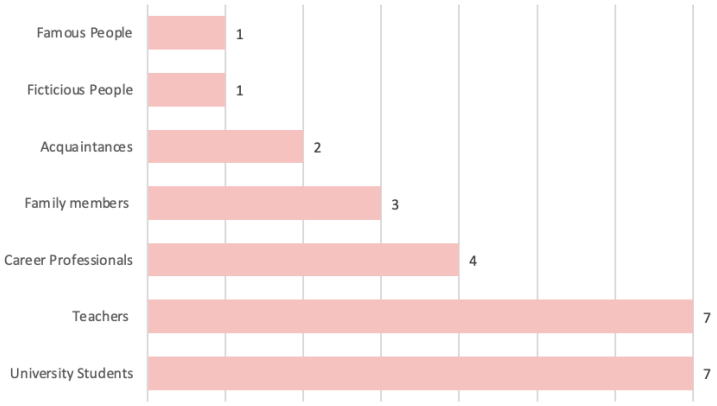

Fig. 3. Mentions of Role Models

Regarding what attributes were found to be relevant for someone to serve as a role model, gender was most often mentioned. The role model having the same gender as the student was seen to positively matter in many cases. Other attributes that were considered important are a role model's age, their passion for computing, and overall, relatability.

Gender While having the same gender is the most commonly identified success factor, it is only mentioned in 5 out of the 16 primary studies. Additionally, the studies present somewhat divisive findings. While S01 and S12 emphasized that role models having the same gender as the participants is a success factor [28], [39], findings in S09 indicate that the gender of the role model is not of big significance.

Age Proximity of age was also mentioned several times. S03 used both career professionals and older students as role models in their intervention. Participants were especially engaged and inspired by the students, explicitly highlighting their being younger as a trait that increased their likeability and relatability [30]. Participants of S04 also point to younger role models, specifically first-year university students, to better motivate girls [31].

Passion for Computing Participants of S07 specifically raved about how their role models were so passionate about coding, and how this inspired them [34]. Also in S03 participants mentioned being inspired by hearing from career professionals who appear passionate about their work. Seeing that women can not only work in computing but enjoy it as well seemed to make an impact on the young girls [30]. Role models break down harmful stereotypes about women's and girl's abilities in computing. Participants of S10 pointed to the fact that role models challenge current stereotypes as a reason for why they are inspired by them [37].

Relatability Findings from the primary studies indicate that the positive impact of role models is dependent on the premise that the role models are sharing their personal stories and experiences with computing, so they are relatable. This is shown for example in S16, where the tutors and the students had only a task-based relationship, and the students reported they had not developed a role model relation to their tutors [43].

5 Discussion

5.1 RQ1: What recent research exists that explores the impact of role models on computing students?

Figure 1 shows that the US has the highest publication frequency out of the countries represented in the primary studies. While this SLR's focus has been gender diversity in computing, it must be pointed out that gender is not a homogeneous aspect in the computing community, but it insects with other identity segments, such as race, ethnicity, sexual orientation, dis/ability, educational level, economic status, geographical origin, etc. [24]. It is an issue that the current research does not represent the diversity of the whole world geographically, which also entails ethnic, cultural, social, and economic components (among others). As seen in figure 1, no countries of the Global South are included in the primary studies, which is a significant gap in the literature. The lack of research from the Global South is a problem because they differ from countries in the Global North in multiple dimensions. Because of this, the studies from the Global North do not have universal relevance, and cannot be used to produce generic claims [25].

A vast majority of the studies were performed on children in K-12 education, as displayed in figure 2B. Due to the adolescent years being a crucial time for the development of interests and sense of identity for children [26], it makes sense to focus efforts on K-12 education when trying to recruit more girls into computing education. It also makes sense that when wanting to improve gender balance by increasing the number of girls, one needs to start with making sure more girls enter computing in the first place. However, research has also found that a lot of girls who start computing education end up dropping out at a higher rate than boys due to the different barriers they face in their education [6]. Because of this, improved retention is arguably an equally important research topic.

The lack of research with a focus on retention has been identified as a gap in the literature by this SLR. More needs to be done to reduce the barriers girls and women face in their higher education computing degrees, such as negative stereotypes [1], [13] and a poor sense of belonging [18].

5.2 RQ2: Who functions as a role model in computing education?

Teachers and students were mentioned most often as role models for women in computing education. Teachers are obvious candidates to be role models, as they serve as the main source of knowledge in an educational setting. Even the students identified as role models were often in a mentoring or tutor position for younger students, indicating that people with a teaching relation to students are influential; thus, are central candidates to becoming role models for them.

Previous studies have found that mentoring programs often provide the mentees with new role models [20]. This is in line with the findings of the primary studies in this SLR; however, mentors or tutors who only shared a task-based relationship with the students did not become role models for their mentees. Sharing details about one's experiences has been identified as an important factor of success for role models in computing due to relatability [10].

In line with the background literature, a few of the primary studies mention same-gendered role models as having a positive impact on girls' interest and proficiency in computing. There were, however, also a few studies where the participants explicitly stated that they did not care about the gender of the role model. According to Drury [13], the gender of the role models has a different impact depending on whether they are used in recruitment or retention, but not a lot of the primary papers seem to specify such a distinction in the use of role models. This should be noted for future research and efforts related to role models. Being conscious about your intent, whether it's recruitment or retention, is important because the importance of different attributes of the role model might differ.

Besides gender, the role model's age was also highlighted. Proximity in age being of importance is not a surprise considering the current literature on role models. When closer in age, the student can more easily perceive similarities with the role model, which is an important part of the process [11], [27]. The other main attribute mentioned was the role model's passion. Showing interest

and knowledge serves as an example that girls and women can also be excited about and successful in computing.

Overall, it can be said that focusing on the attributes of role models is a gap in the current literature. The fact that we were only able to extract a few different attributes and that a lot of the primary papers did not mention them in any detail at all indicates that this is a current oversight in recent research. This gap should be addressed, considering the findings here which indicate that role model attributes might be of importance in order to make sure the intervention efforts are as effective as possible.

5.3 Limitations

A limitation of the SLR process was not including other aliases for role models in the search query for the SLR. The query looked at the specified terms in the title, abstract, and keywords of all papers in Scopus. Findings from the primary studies indicate that e.g. mentors and teachers can often function as effective role models too. By only including "role models" as a term in the search query, some studies that might present relevant findings about role models without mentioning this term in their title, abstract, or keywords were not found.

In addition, by specifying English to be the language of the study as an inclusion criterion, due its status as the lingua franca of scholarly research, we may have lost relevant papers focusing on local initiatives. This may have contributed to the imbalance regarding the geographical distribution of the studies.

Another limitation of the methods used in the SLR process is only using Scopus as the database for finding papers. Other digital libraries such as Google Scholar, ACM Digital Library, and IEEExplore could be used to perform an exhaustive search. While this choice was made with time limitations in mind, readers should be aware of the potential gap in the selection of primary studies.

6 Conclusion

In this study, a systematic literature review has been performed to create an overview of recent research and findings of papers addressing the use of role models in computing education to improve gender diversity. 16 primary studies between 2016 and 2023 were identified through the selection process and then analyzed.

All of the 16 primary studies were from the Global North, revealing a gap in the literature about the coverage of experiences and studies from the Global South. Most of the studies were from the US. The research field as it stands today does not represent diversities around the world, and more needs to be done to cover these gaps.

Teachers, both in higher education and K-12, and university students were the groups most commonly identified as role models throughout the primary studies. These findings indicate that mainly people with a personal relationship with the students function as role models. Furthermore, it shows that focus

should be put on teachers, as well as peers to remind them of the great influence they have on students. Relatability was found to be an important trait of a role model, regarding gender, age, and passion, and it also seem crucial that the role model can share their personal experiences with the students.

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Appendix A

Table 3. Overview of the primary papers (part 1)

Study [1]	Paper
S01 [28]	D. Lamers and R. Mason, **"Advertising cs/it degrees to female students in australia"**, in Proceedings of the 20th Australasian Computing Education Conference, ser. ACE '18, Brisbane, Queensland, Australia: Association for Computing Machinery, 2018, pp. 1–8, isbn: 9781450363402. doi: 10. 1145/3160489.3160497.
S02 [29]	M. Fulcher, K. Schroeder, and J. Rabung, **"Barbie, i can ('t) be a computer engineer: The impact of barbie text and images on girls' computing performance"**, Journal for STEM Education Research, pp. 1–27, 2023.
S03 [30]	C. Lang, J. Fisher, A. Craig, H. Forgasz, et al., **"Computing, girls and education: What we need to know to change how girls think about informationtechnology."**, Australasian Journal of Information Systems, vol. 24, 2020.
S04 [31]	Z. Şahin Timar and Ö. Mısırlı, **"Effective strategies for encouraging girls in informatics"**, in International Conference on Human-Computer Interaction, Springer, 2023, pp. 377–392.
S05 [32]	L. Vasconcelos, F. Ari, I. Arslan-Ari, and L. Lamb, **"Female preservice teachers stereotype computer scientists as intelligent and overworked white individuals wearing glasses"**, Computers & Education, vol. 187, p. 104 563, 2022.
S06 [33]	T. Berg, A. Sharpe, and E. Aitkin, **"Females in computing: Understanding stereotypes through collaborative picturing"**, Computers & Education, vol. 126, pp. 105–114, 2018.
S07 [34]	M. Gutica, **"Fostering high school girls' interest and attainment in computer science"**, in Proceedings of the 26th ACM Conference on Innovation and Technology in Computer Science Education V. 1, ser. ITiCSE'21, Virtual Event, Germany: Association for Computing Machinery, 2021, pp. 471–477, isbn: 9781450382144. doi: 10.1145/3430665.3456353.
S08 [35]	L. El-Hamamsy, B. Bruno, C. Audrin, et al., **"How are primary school computer science curricular reforms contributing to equity? impact on student learning, perception of the discipline, and gender gaps"**, arXiv preprint arXiv:2306.00820, 2023.

[1] The primary papers are sorted alphabetically and given an ID in the format S#, ranging from 01 - 16. The S is short for study.

Table 4. Overview of the primary papers (part 2)

S09 [36]	E. Taylor-Smith, C. Barnett, S. Smith, M. Barr, and C. Shankland, **"Participantcentred planning framework for effective gender balance activities in tech"**, in Proceedings of the 2022 Conference on United Kingdom & Ireland Computing Education Research, ser. UKICER '22, Dublin, Ireland: Association for Computing Machinery, 2022, isbn: 9781450397421. doi: 10.1145/3555009.3555016.
S10 [37]	S. Clayton, C. Hawkins, and J. Brandsema, **"Rural implementation of girls' programming network (gpn)"**, Australian and International Journal of Rural Education, vol. 31, no. 2, pp. 38–45, 2021.
S11 [38]	J. G. Stout, B. Tamer, H. M. Wright, L. A. Clarke, S. Dwarkadas, and A. M. Howard, **"The grad cohort workshop: Evaluating an intervention to retain women graduate students in computing"**, Frontiers in psychology, vol. 7, p. 2071, 2017.
S12 [39]	A. Sullivan and M. U. Bers, **"The impact of teacher gender on girls' performance on programming tasks in early elementary school"**, Journal of Information Technology Education. Innovations in Practice, vol. 17, p. 153, 2018.
S13 [40]	Y. Rankin, M. Agharazidermani, and J. Thomas, **"The role of familial influences in african american women's persistence in computing"**, in 2020 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT), IEEE, vol. 1, 2020, pp. 1–8.
S14 [41]	M. E. Vachovsky, G. Wu, S. Chaturapruek, O. Russakovsky, R. Sommer, and L. Fei-Fei, **"Toward more gender diversity in cs through an artificial intelligence summer program for high school girls"**, in Proceedings of the 47th ACM Technical Symposium on Computing Science Education, ser. SIGCSE'16, Memphis, Tennessee, USA: Association for Computing Machinery, 2016, pp. 303–308, isbn: 9781450336857. doi: 10.1145/2839509.2844620.
S15 [42]	A. Alshahrani, I. Ross, and M. I. Wood, **"Using social cognitive career theory to understand why students choose to study computer science"**, in Proceedings of the 2018 ACM Conference on International Computing Education Research, ser. ICER '18, Espoo, Finland: Association for Computing Machinery, 2018, pp. 205–214, isbn: 9781450356282. doi: 10.1145/3230977.3230994.
S16 [43]	B. Spieler, J. Mikats, S. Valentin, L. Oates-Indruchová, and W. Slany, **""remotementor" evaluation of interactions between teenage girls, remote tutors, and coding activities in school lessons"**, in Learning and Collaboration Technologies. Designing, Developing and Deploying Learning Experiences: 7th International Conference, LCT 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, July 19–24, 2020, Proceedings, Part I 22, Springer, 2020, pp. 547–567.

[1] The primary papers are sorted alphabetically and given an ID in the format S#, ranging from 01 - 16. The S is short for study.