Gender Diversity in Software Engineering: A Systematic Mapping

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ABSTRACT
Gender diversity in software engineering has become a focus of growing interest in recent years. As the field continues to grow and evolve, it is crucial to understand the current state of research on this topic. This systematic mapping aims to provide a comprehensive overview of the existing literature on gender diversity in software engineering by analyzing 58 relevant studies from reputable academic databases and conferences relevant to the field of software engineering. This study addresses seven research questions concerning bibliographic details, methodologies employed, distribution across the Software Engineering Body of Knowledge (SWEBOK), data sources, types of empirical research, main topics discussed within the scope of gender diversity, and the challenges faced by women in software engineering. These findings will provide valuable insights for researchers and practitioners seeking to promote gender diversity and inclusivity in software engineering.

General Terms
Systematic mapping, Gender diversity, Software engineering, SMS

Keywords
Systematic mapping, Gender diversity, Software engineering, SMS.

1. INTRODUCTION
In recent years, gender diversity in software engineering (SE) has received significant attention and appreciation in research, reflecting a growing understanding of its importance. As the field expands and undergoes continuous development, it has become important to delve into the latest research and understand the current state of gender diversity research in SE. Software Engineering is a complex task that includes social and technical elements that face the challenges of continuous evolution. Women represent less than 10% of the total developers in both software development and open-source projects. This underrepresentation is likely attributed to workplace conditions that reflect male gender bias [1]. In 1984, women's participation in computer science increased to 37%, but since 1995 until now, despite the increase in female participation in information and communications technology, the percentage of workers in general industry has not changed from male to female [2]. Gender diversity in the workplace has helped to better exchange ideas and increase creativity and innovation. Also, it assists in making better decisions [3]. Diversity is defined as the diversity of representations within a group, based on a wide range of facets and characteristics. Diversity is also related to the groups of people involved in software development practices and emerging technical designs. Additionally, gender is the most applied dimension of diversity in software development due to the lack of women in computer science and technology professions [4]. In the past, it was seen that designing devices was a male domain and that programming was a profession for women [4]. This research seeks to provide an in-depth analysis of gender diversity in software engineering. It also aims to provide bibliographic details of these publications and compile the main findings in the literature related to gender diversity. Additionally, it explores the distribution of gender diversity across different Software Engineering Body of Knowledge areas (SWEBOK), highlighting where gender representation may be more pronounced or lacking. Furthermore, it categorizes the data sources used in empirical research on gender diversity in software engineering and provides insight into the methodologies used and the types of empirical research conducted, providing a nuanced understanding of the research landscape. Moreover, this paper explores topics discussed in various papers related to gender diversity in software engineering. This investigation leads to identifying the specific challenges faced by women in this field.

This paper is organized as follows. Section 2 presents the previous related systematic and mapping literature review studies published in gender diversity in the SE field. In Section 3, it presents the SMS methodology, research questions, selection criteria, and process. Section 4 shows and discusses the results. Finally, in Section 5 it summarizes and presents the conclusions.

2. RELATED WORK
Gender diversity in software engineering (SE) has been addressed in different studies. Rodríguez-Pérez et al. [5] conducted a systematic literature review of 131 studies published from 2003 - 2021, illustrating observed diversity in software engineering, identifying gaps in the current literature, and creating a call for future work on observed diversity in software engineering. They identified the issues they studied and reported the results. They also studied methods, models, tools and processes that have been proposed to help with perceived diverse issues. Finally, they identify limitations that have been reported when studying the diversity observed in software engineering. They found that individual studies focus on demonstrating gender differences or gender bias rather than developing methods and tools to mitigate gender diversity problems. In addition, observed aspects of diversity related to SE participants' race, age, and disability need further analysis in software engineering research. Similarly, the researchers sought to understand the importance of diversity in software engineering research and more specifically in Agile methodologies by conducting a systematic mapping of 221 studies from 2001 - 2018. They found that 129 papers discussed gender diversity, of which 83 focused on women [6]. On the other hand, they used a systematic mapping study on 19 studies

published from 2010 - 2021, to obtain information about the relationship between information technology and gender from an entrepreneurship perspective. They found that while the number of studies is slowly increasing, there is still a lack of current research. The obstacles that are repeated in many studies are gender stereotypes and gender-related social roles [7]. Similarly, Patón-Romero et al. [8] conducted a systematic mapping study. The researchers analyzed the latest developments related to gender equality and IT operations from 15 studies published between 2016 - 2021. The results showed the newness of the field, and the presence of a number of challenges, such as a lack of best practices to address gender equality. Additionally, due to the lack of papers mentioning aspects of gender diversity in the field of software architecture (SA). Researchers have expanded the research to include aspects of gender diversity in software engineering (SE) and they didn't limit the search to particular years. They found that the majority of publications related to aspects of gender diversity within SE did not focus on analyzing state-of-the-art industry research experiences or SA, and that 17.43% of papers had women as first authors [9].

In this research, the systematic mapping study provides a comprehensive analysis of gender diversity in software engineering, comprising 58 papers published in the last five years. It presents the bibliographic details of these publications and synthesizes the key findings reported in the literature concerning gender diversity within the field. Additionally, it explores the distribution of gender diversity across various domains of the Software Engineering Body of Knowledge (SWEBOK), shedding light on areas where gender representation may be more pronounced or lacking. Additionally, it classifies the types of empirical research conducted, whether qualitative, quantitative, or mixed methods, providing a nuanced understanding of the research landscape.

3. METHODOLOGY

This systematic mapping follows the guideline developed by Kitchenham et al. [10]. It involves three stages: planning, conducting, and reporting. The planning stage focuses on identifying the need for the review and initiating a protocol to guide the research process. The conducting stage focuses on collecting relevant research, selecting primary studies, assessing study quality, and extracting and synthesizing data. The reporting phase focuses on writing a report that summarizes the findings of the review. A team of three doctoral students conduct this systematic mapping, taking responsibility for all aspects of the review process. The team also validates the review protocol and closely monitors the review's progress at each stage.

3.1 Planning the Review - Fundamental Questions

The aim of this research is to explore gender diversity in software engineering. Therefore, it refines the aim in six research questions described as follows:

RQ1: What is the bibliographic information for the publications on gender diversity in software engineering?

RQ2: What types of methodologies are used to explore gender diversity in software engineering?

RQ3: How are the publications on gender diversity distributed across the different areas of the Software Engineering Body of Knowledge (SWEBOK)?

RQ4: What are the sources of data for the publications on gender diversity in software engineering?

RQ5: What types of empirical research have been conducted on gender diversity in software engineering?

RQ6: What are the main topics that are investigated within the area of gender diversity in software engineering?

After analyzing and extracting the data, the researchers recognized the significance of addressing gender-related challenges in software engineering. Therefore, an additional research question was introduced into the study. This question is outlined as follows:

RQ7: What challenges are encountered by women in the domain of software engineering?

3.2 Identification of Research - Search Strategy

Relevant studies were collected from four reputable academic databases, including: ACM Digital Library, IEEE Xplore, ScienceDirect, SpringerLink. The study emphasized the inclusion of papers presented at two well-known conferences in the field of software engineering: International Conference on Mining Software Repositories, and International Conference on Software Engineering.

These electronic databases were chosen for their comprehensive coverage of software engineering literature and their advanced search capabilities that support keyword searches. The search timeframe covered the publications from 2019 to 2023, capturing the field's most recent research over the past five years.

A well-constructed search string is essential for capturing the most relevant studies within the research domain. This search string includes gender-related terms such as "gender", "female", "male", "woman", "man" and similar keywords to ensure comprehensive coverage of relevant studies. Additionally, the use of the asterisk (*) in "mining software repositor*" serves as a wildcard, enabling the inclusion of variations such as "repositories" and "repository". The search terms were applied to the titles, abstracts, and keywords of the papers in the identified electronic databases.

Search Key

(("gender" OR "female" OR "male" OR "woman" OR "man" OR "women" OR "men")

AND

("mining software repositor*"))

OR

(("gender" OR "female" OR "male" OR "woman" OR "man" OR "women" OR "men")

AND

("software engineering" AND "Mining"))

3.3 Study Selection Criteria and Procedures

Inclusion and exclusion criteria were designed to ensure the inclusion of studies that align with the scope and objectives of this review, while excluding studies that do not meet the specified criteria.

3.3.1 Inclusion criteria:

- Studies that specifically address gender diversity within the context of software engineering

- Studies that belong to the years between 2019 to 2023

3.3.2 *Exclusion criteria:*

- Studies that primarily focus on technical aspects of software engineering without addressing gender diversity.

- Studies published on training, editorials, article summaries, interviews, prefaces, news, reviews, correspondence, tutorials, poster sessions, workshops, and panels.

- Studies that are not written in English.

- Studies that use gender as a control variable, without theoretical grounding or elaboration on results, were excluded to maintain focus on the interplay between software engineering and gender.

A multi-stage methodology was employed, using Rayyan, Zotero, Tableau and Python programming language. Rayyan is a web-based application designed to facilitate the management and streamlining of systematic reviews. Two independent researchers conducted title and abstract screening at stages 2 and 3. This ensured a thorough and unbiased evaluation. At each stage, papers were included only if both researchers agreed on their relevance to the topic according to the predefined inclusion and exclusion criteria. If there was disagreement, the paper was moved to the next stage for further discussion.

Figure 1 illustrates the stages of the study selection process. An initial search of various electronic databases yielded 1,747 potential papers (Stage 1). This number is reduced to 114 papers (Stage 2) based on title review and duplication removal. Abstract screening further refined the selection to 64 papers (Stage 3). A comprehensive review of the full text resulted in the final selection of 58 papers (Stage 4).

Additionally, Zotero was used to extract some data such as the authors, publication year, and the publication library. Moreover, Tableau was used for visualizing the results.

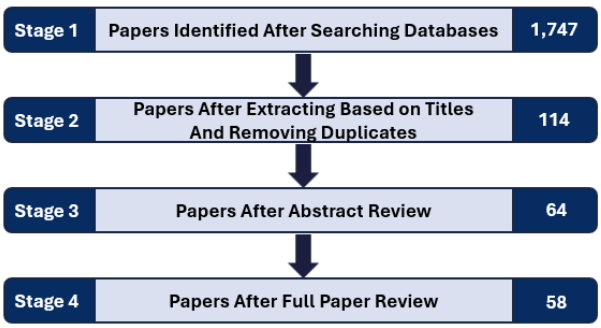

Fig 1: Stages of the study selection process.

4. RESULTS AND DISCUSSION

This section provides quantitative findings from the reviewed papers on gender diversity within the field of software engineering. Following the protocol outlined in Section 3, 58 primary studies were analyzed.

Table 1: Reviewed papers and their contributed topic

Year	Studies	Topics	Data sources
2019	[11]	Contribution in OSS	Stack overflow
	[12]	Contribution in OSS	GitHub
	[13]	Contribution in OSS	Stack overflow
	[14]	Contribution in OSS	Others
	[15]	Gender Recognition	Android
	[16]	Effect of Gender Bais in OSS	GitHub
	[17]	Effect of Gender Bais in OSS	Others
	[18]	Effect of Gender Bais in OSS	Others
	[19]	Effect of Gender Bais in Code Review	Others
	[20]	Job Fairness	Survey
	[21]	Job Fairness	Survey
	[22]	Ethnic and Gender Diversity	Others
2020	[23]	Contribution in Software Projects	Others
	[24]	Challenges of Female in SE	Stack overflow
	[25]	Job Fairness	Interview
	[26]	Contribution in OSS	GitHub
2021	[27]	Challenges of Female in SE	Survey
	[28]	Gender Recognition	Stack overflow
	[29]	Gender Recognition	mobile log
	[30]	Contribution in OSS	Survey
	[31]	Ethnic and Gender Diversity	Stack overflow
	[32]	Ethnic and Gender Diversity	Others
	[33]	Ethnic and Gender Diversity	GitHub
2022	[34]	Contribution in OSS	Others
	[35]	Challenges of Gender during Pandamic	Survey
	[36]	Effect of Gender in App Usability	Others
	[37]	Contribution in Software Projects	Others
	[38]	Gender Recognition	Others
	[39]	Effect of Gender in Github	GitHub
	[40]	Challenges of Female in SE	Survey
	[41]	Survival Strategies for Female	Survey
	[42]	Effect of Gender Bais in OSS	GitHub
	[43]	Females in Hackathon	Survey
	[44]	Effect of Gender Bais in OSS	GitHub
	[45]	Challenges of Female in SE	Others
	[46]	Job Fairness	Survey
	[47]	Survival Strategies for Female	Survey
	[48]	Challenges of Female in SE	Mobile review
	[49]	Gender Recognition	Mobile review
	[50]	Contribution in OSS	GitHub
	[51]	Contribution in OSS	Others
	[52]	Contribution in OSS	GitHub
	[53]	Effect of Gender Bais in Code	Others

2023		Review	
	[54]	Females in Hackathon	Others
	[55]	Ethnic and Gender Diversity	GitHub
	[56]	Survival Strategies for Female	Interview
	[57]	Effect of Gender in App Review	Mobile review
	[58]	Job Fairness	Others
	[59]	Challenges of Female in SE	Survey
	[60]	Contribution in OSS	Others
	[61]	Gender Recognition	Others
	[62]	Gender in Education	Others
	[63]	Gender in Education	Others
	[64]	Gender Recognition	Others
	[65]	Job Fairness	Others
	[66]	Effect of Gender Bais in LLM	Survey
	[67]	Gender Recognition	Survey
	[68]	Survival Strategies for Female	Survey

To answer RQ1, "What is the bibliographic information for the publications on gender diversity in software engineering?", a quantitative analysis was conducted to provide comprehensive details of publication years, the libraries or databases where these publications are indexed, the contributing authors, and the publications' venues. This bibliographic information aims to create a foundation for understanding the research landscape on this topic.

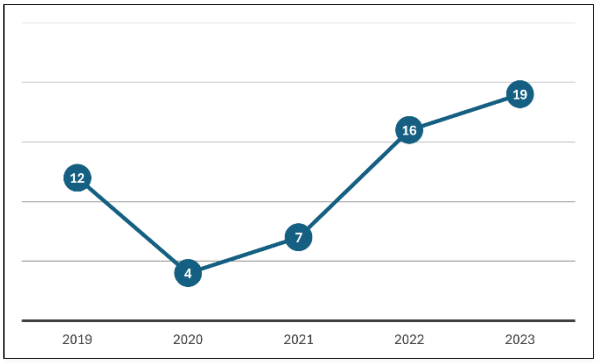

Fig 2: Number of publications per year

Over recent years, there has been a noticeable shift in the level of attention the research community has allocated to gender diversity in software engineering as presented in Figure 2. This trend covers five years from 2019 to 2023. In 2019, there were 12 published studies on this topic. However, the following year, 2020, witnessed a significant drop to only 4 papers. While the exact cause of this decrease remains unspecified, it is reasonable to attribute it to the disruptive impact of the global COVID-19 pandemic.

Nevertheless, the commitment to examining gender diversity in software engineering recovered to 7 publications in 2021. The subsequent years have seen a continuous upswing in publication numbers. In 2022, the literature expanded significantly with 16 papers, emphasizing the research community's growing interest in the importance of gender diversity in software engineering practices. This upward trend peaked in 2023 with 19 publications, marking the highest annual output within the observed time frame. This peak is indicative of the increasing discussion of gender diversity in the academic domain, proof that it has become a more prominent and crucial topic within the research community.

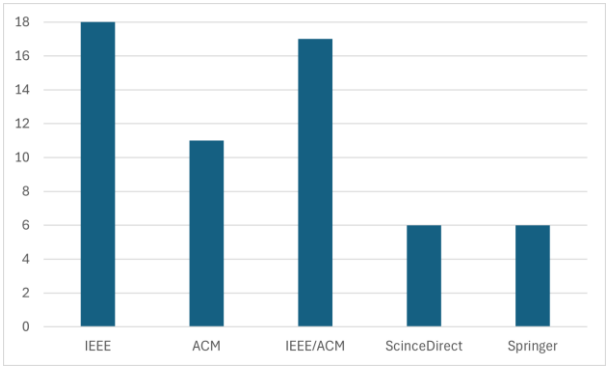

Fig 3: Number of publications per library.

Figure 3 presents the distribution of articles gathered from four online libraries: IEEE, ACM, ScienceDirect and Springer to provide insight into the research community. IEEE has an extensive repository of the topic compared to other databases with 18 publications, reflecting IEEE's influence as a primary resource for current research. Following that, the ACM library has less contribution than IEEE, with 11 papers. Meanwhile, the collaborative IEEE/ACM database reflects a significant number with 17 publications. ScienceDirect and Springer present fewer published works, with 6 papers each. Although these platforms have a broader academic scope, it indicates that gender diversity in software engineering can be considered a valuable research topic in these libraries.

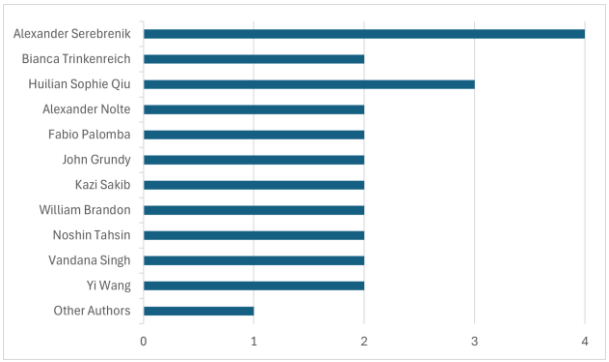

Fig 4: Number of publications per author.

Figure 4 highlights the most productive authors who frequently publish and have made notable contributions to the topic. It shows that the top contributor is Alexander Serebrenik, who has 4 publications. This number positions Serebrenik as a key voice in ongoing discussions. Huilian Sophie Qiu is next, with 3 publications.

Nine other authors, including Bianca Trinkenreich, Alexander Nolte, Fabio Palomba, John Grundy, Kazi Sakib, William Brandon, Noshin Tahsin, Vandana Singh, and Yi Wang have contributed with 2 publications each. Other authors within the selected papers have 1 publication each. Despite the differences in quantity, these authors' contributions add valuable insights to the field.

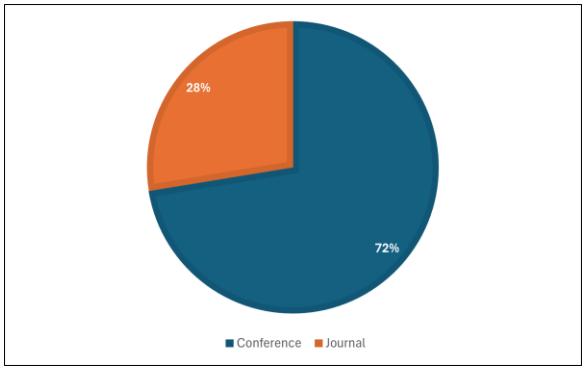

Fig 5: Distribution of publications based on publication venue.

The examination of the 58 reviewed papers reveals that conference proceedings are the primary publication avenue, accounting for 72% of the publications in Figure 5. At the same time, journal articles contribute a smaller share with 28% of the publications. This distribution suggests that conferences are currently the primary avenue for scholars to share their findings and engage with the community about gender diversity in the field of software engineering.

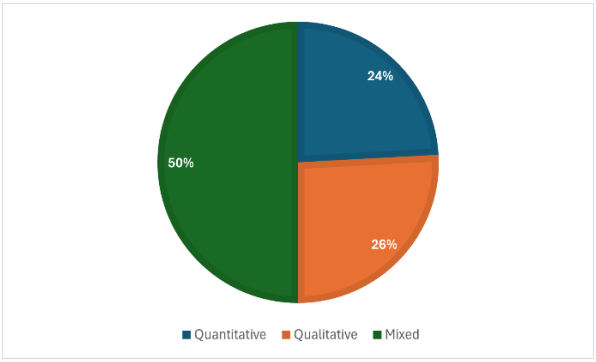

Fig 6: Distribution of publications based on the utilized methodology.

Regarding RQ2, Figure 6 provides a clear breakdown of the methods used to analyze gender diversity in software engineering. 50% of the papers adopted a mixed-methods approach, integrating quantitative and qualitative techniques to gain a comprehensive understanding. This suggests a preferable approach in using statistical data and narrative insights to construct a holistic perspective on the field. 26% of the studies applied quantitative methods, indicating a bigger portion of research using numerical data and statistical analysis. The remaining 24% used qualitative methods, focusing on the contextual richness of different sources such as surveys. These differences in research methods underscore the complexity of studying gender diversity in software engineering and highlight the value of applying diverse approaches to fully understand gender diversity in software engineering.

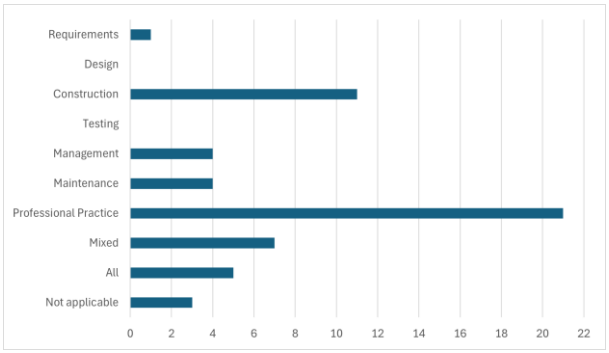

Fig 7: Number of publications per area of the SWEBOK

Figure 7 highlights the specific areas of the Software Engineering Body of Knowledge (SWEBOK) [69] that the 58 selected studies cover to answer RQ3. The chart presents the distribution of these papers across different phases. While the 'Professional Practice' aspect of software engineering is well covered, with 21 papers, the 'Construction' phase is another key area of interest, with over 10 papers. However, fewer papers are dedicated to the 'Requirements', 'Management', and 'Maintenance' phases, potentially indicating gaps in the literature that future research needs to fill.

7 papers are categorized under 'Mixed,' indicating they include multiple phases within the SWEBOK. Most of the research focuses on the 'Software Engineering Professional Practice' with 'Software Engineering Management' phases. Other studies extend their coverage to 'Design' with 'Testing', the intersections between 'Construction' and 'Software Professional Practice' and between 'Construction' and 'Quality'. However, a small portion is categorized as 'Not applicable,' which refers to theoretical discussions that don't align with a specific SDLC phase.

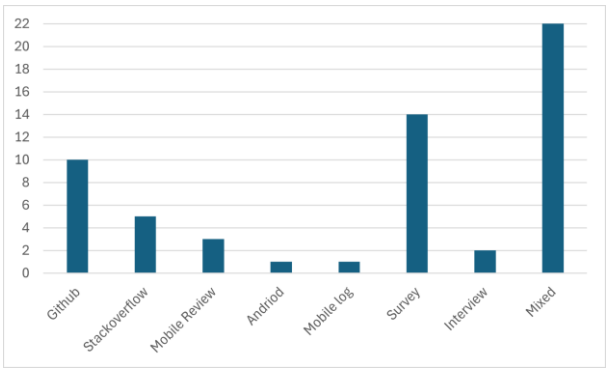

Fig 8: Distribution of the publication based on the data source.

To answer RQ4, Figure 8 shows diverse sources of data the research used. Most studies, 22 studies, have used 'Mixed' data sources, which combine various sources including surveys, interviews, and data mining to provide a richer view. However, surveys are the next common data collection method demonstrated in the articles, with 14 studies employing them. The common use of surveys may rely on researchers' need to capture attitudes, experiences, and opinions and facilitate quantitative and qualitative data analysis. GitHub and Stack Overflow were used as data sources in 10 and 5 studies, respectively, focusing on investigating gender diversity within real-world software development environments. Other sources, such as 'Mobile Review' and 'Mobile Log,' were employed less often, while interviews were among the least common data collection methods.

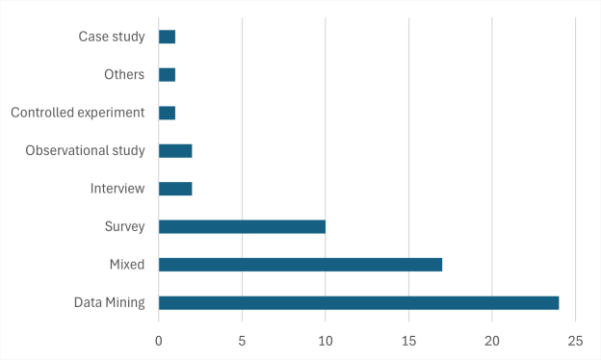

Fig 9: Number of publications per empirical research.

Regarding RQ5, Figure 9 provides insight into the empirical study types. Data mining is the most common type, demonstrating the favored approach among researchers for data on gender diversity. Followed by Mixed methodologies, which represent a combination of various data sources. While the survey approach was employed on 10 studies, interviews were much fewer, with only 2.

Case studies, observational studies, and controlled experiments are also represented in a small number of papers, highlighting the research community's engagement with in-depth analysis of specific instances and behaviors within software engineering environments. The diversity of empirical approaches reflects the complex nature of gender diversity research in this domain.

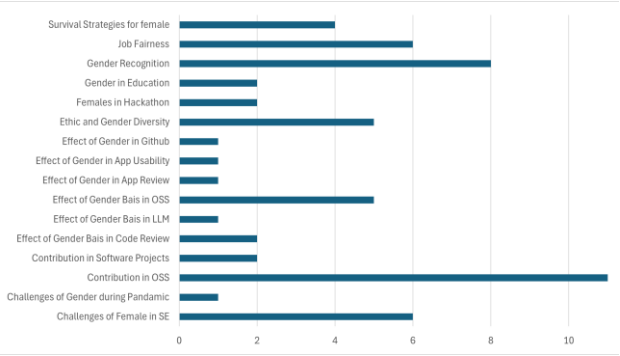

Fig 10: Distribution of the publication based on the addressed topic

Figure 10 illustrates the topics addressed to answer RQ6 in the selected papers. There were 16 different topics discussed in gender diversity in software engineering during the period from 2019 to 2023. It is clearly seen that "Contribution to OSS" is the most frequently covered topic in literature, indicative of a deep interest in examining how gender diversity is revealed in Open-Source Software. Such analyses are crucial in guiding efforts to foster a more diverse environment in software engineering, particularly within open-source projects, which are often at the forefront of innovation and community-driven development. Then, there is 'Gender Recognition,' which identifies or predicts a person's gender based on various types of data. Another popular topic among the papers is 'Challenges of Females in SE' and 'Job Fairness,' reflecting significant interest in the obstacles that women face in the field. Other significant areas of study include "Effect of Gender Bias in OSS" and "Ethics and Gender Diversity," which delve into how gender perceptions influence participation and evaluation within software projects, as well as emphasizing the intersection of ethical considerations and gender in creating inclusive work environments. The "Survival Strategies for Females" is another popular area, highlighting the methods women in software engineering employ to thrive in the industry. However, each topic offers a piece of the larger puzzle of how to create a more inclusive and equitable field.

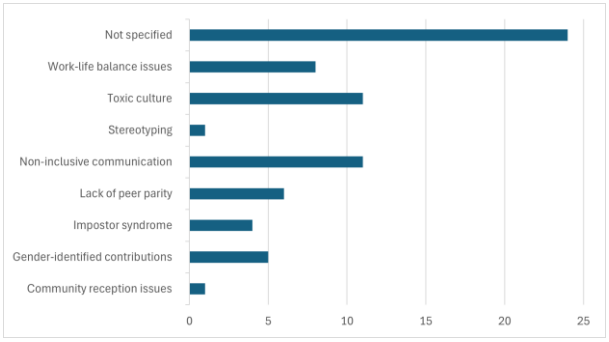

Fig 11: Distribution of the publication based on the highlighted challenges.

The literature examination revealed an interesting observation concerning the challenges of gender diversity in software engineering, presented in Figure 11 to answer RQ7. It has been found that many papers discussed the challenges faced by women, with no mention of the specific challenges faced by men. This lack of data regarding men's difficulties suggests an area of research that has yet to be extensively explored. It is essential to recognize that the experiences of all genders can provide a more comprehensive understanding of the diversity within software engineering. This gap may provide an opportunity for future research to investigate the unique challenges that men may face and offer a holistic view of gender diversity in the field.

The categorization of the challenges is adopted from [70]. While most of the papers did not specify any challenges, some papers highlighted various challenges. 'Non-inclusive communication' and 'Toxic Culture' are primary concerns. While 'non-inclusive communication' points to environments where interactions do not fully consider or integrate the diverse perspectives of women, 'Toxic Culture' refers to unwelcoming or harmful workplaces for women. Issues of 'Work-life balance issues', 'Gender-identified contributions' and 'Lack of peer parity' are also frequently discussed, reflecting the difficulty in managing professional and personal life demands, the struggle to recognize contributions and challenges in achieving equal status. Lastly, 'Impostor syndrome', 'Community reception issues' and 'Stereotyping' are cited less frequently but remain vital as they represent biases that can affect women's experiences in software engineering.

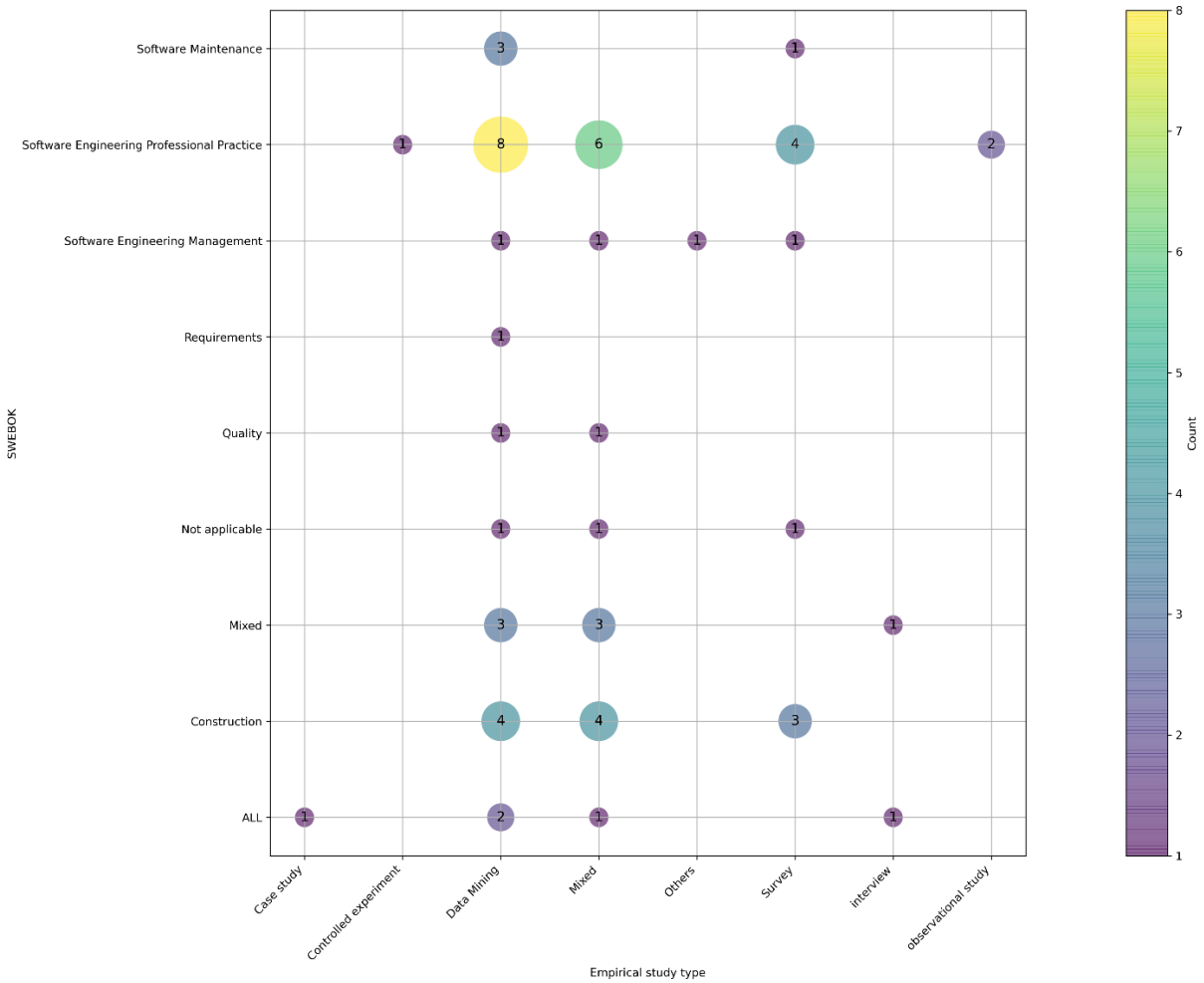

Fig 12. Distribution of papers based on the relation between SWEBOK and empirical study type

Figure 12 illustrates the distribution of various empirical study types across different Software Engineering Body of Knowledge (SWEBOK) areas. It reveals that the most frequent study type within the "Software Engineering Professional Practice" category is data mining, with a count of 8, followed by notable counts for mixed method and survey. The "Software Maintenance" area predominantly uses data mining studies. Using other empirical study types, such as case studies and controlled experiments, could provide deeper insights into gender diversity in this area. The "Construction" area shows an equal distribution between data mining and mixed studies, with slightly fewer studies utilizing survey methods. Areas such as requirements and quality show fewer empirical study types, with a single study type being used for requirements (data mining) and two study types for quality (data mining and mixed). These findings suggest a strong preference for in-depth analysis studying gender diversity in requirements and quality by employing various types of empirical methods such as surveys, case studies, and controlled experiments.

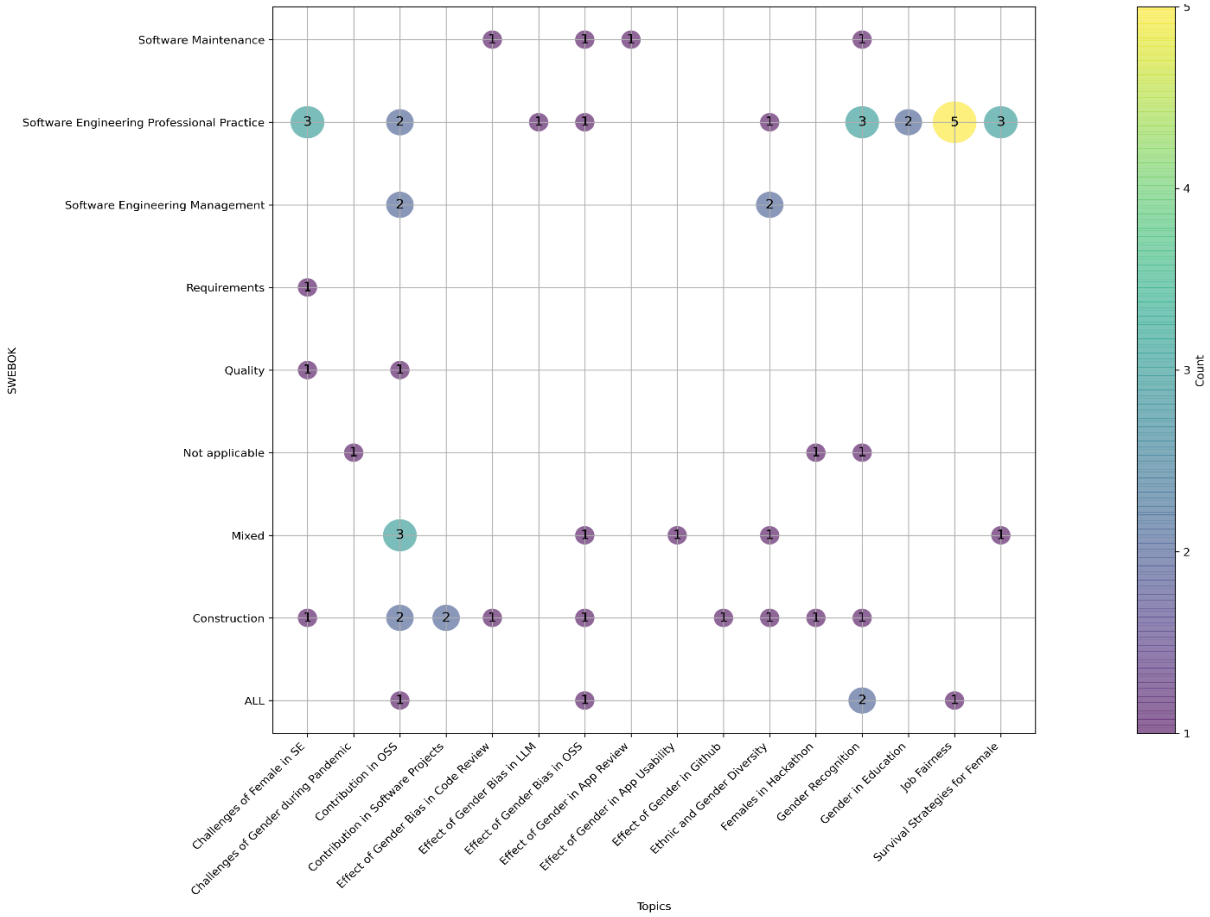

Fig 13: Distribution of papers based on the relation between SWEBOK and main topics discussed within the scope of gender diversity.

Figure 13 presents the distribution of the main topics discussed within the scope of gender diversity across different Software Engineering Body of Knowledge (SWEBOK) areas. It demonstrates that in the "Software Engineering Professional Practice" area, topics such as "Job Fairness," followed by "Challenges of Female in SE," "Gender Recognition," and "Survival Strategies for Female" are highly presented. This indicates a significant focus on gender-related issues within the professional practice of software engineering. In contrast, the Requirements area has the least coverage, with only one study focusing on the challenges faced by females in SE. This area remains under-explored and needs further investigation using various topics to achieve a comprehensive understanding of gender dynamics in the field.

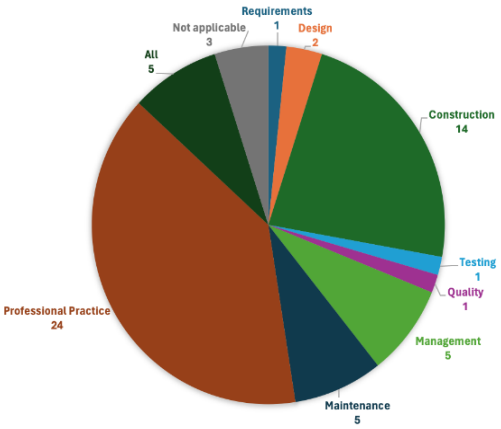

Fig 14: Distribution of papers based on Software Knowledge Area

Figure 14 displays the distribution of research papers across the Software Knowledge Area, providing valuable insights into focal points for exploring gender diversity within software development contexts. It is noteworthy that “Professional Practice” stands out as the most widely investigated area, with a count of 24 papers, showing the significant attention given to workplace dynamics and professional behavior in gender diversity discussions. In addition, there is a notable focus on “Code Constructure” suggesting a deliberate effort to examine gender dynamics within technical fields. Furthermore, the figure confirms that gender discussions are particularly prominent during the “Maintenance” and “Management” phases, in contrast to the relatively less emphasis during the “Design,” "Requirements," “Testing,” and “Quality” phases, showing small differences across different area of the software development process. In this figure, the 'Mixed' category, which represents the combination of two phases, is not shown. Instead, they separately count each phase within the mixed category. For example, if a paper combines the 'Software Engineering Professional Practice' and 'Software Engineering Management' phases, they add one point to both 'Software Engineering Professional Practice' and 'Software Engineering Management'. Some papers span across all phases of the SDLC, meaning a comprehensive exploration of the implications of gender diversity throughout the software development process.

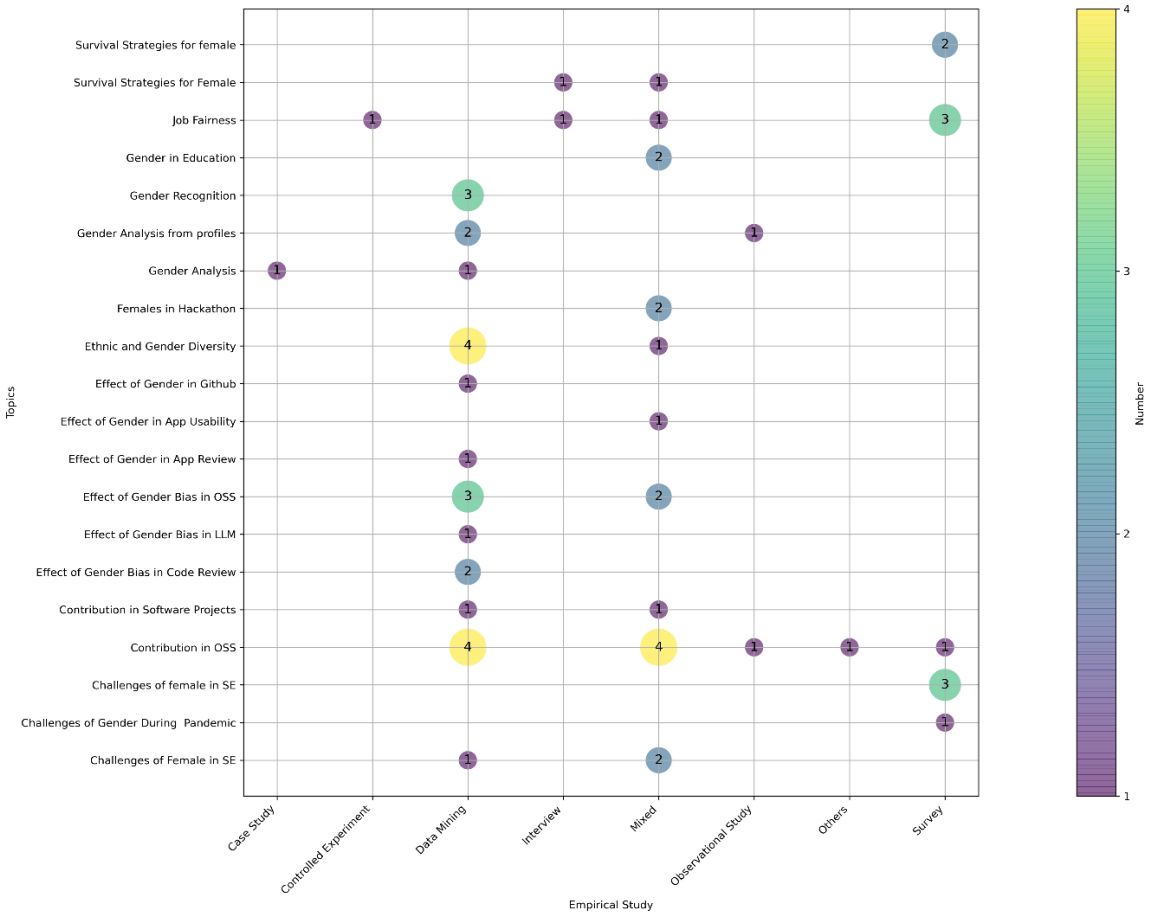

Fig 15: Distribution of papers based on the relation between main topics discussed within the scope of gender diversity and empirical study type.

Figure 15 demonstrates the distribution of empirical study types across a spectrum of the main topics explored within the scope of gender diversity. Notably, within the topic of "Contribution in OSS," the predominant empirical studies utilized are "Data Mining" and "Mixed", with a count of 4, closely trailed by "Survey," "Observation Study," and "Other". Similarly, in the context of "Ethnic and Gender Diversity," "Data Mining" emerges as the most frequently employed empirical study, with a count of 4, followed by "Mixed". Moreover, the figure shows that 'Data Mining' was used to explore areas like 'Gender Recognition' and the 'Effect of Gender Bias in OSS', highlighting its various uses. Furthermore, it reveals that "Survey" methodologies were instrumental in uncovering insights into "Job Fairness" and "Challenges of Female in SE", underscoring the diverse investigative avenues embraced within gender diversity scholarship. Empirical studies like case studies and controlled experiments are less commonly used in gender diversity topics, with a single study type being used for “Job fairness (Controlled Experiment)” and “Gender analysis (Case Study)”. These findings indicate a preference for detailed analysis in these topics, often employing various empirical methods such as surveys, interviews, and observation studies.

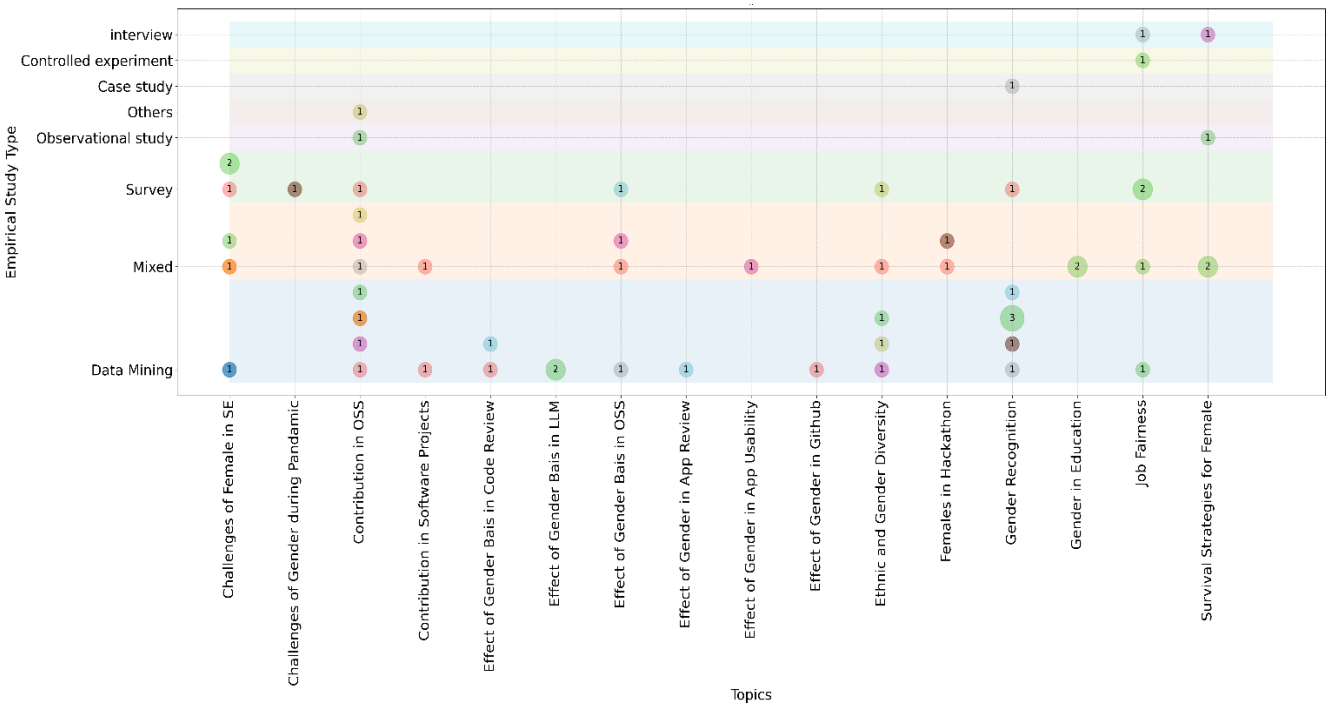

Fig 16: Stages of the study selection process

Figure 16 demonstrates a comprehensive visualization that captures the connection of various research dimensions within the systematic mapping review focused on gender diversity in software engineering. It clarifies the distribution and frequency of research topics across different categories of the Software Engineering Body of Knowledge (SWEBOK), aligned with the types of empirical studies conducted in the field. The x-axis categorically displays the specific research topics addressed within the 58 papers analyzed, ranging from “Challenges of Female in SE” to “Survival Strategies for Female”. The y-axis outlines the types of empirical studies—such as surveys, interviews, observational studies, and controlled experiments—highlighting the approaches researchers have adopted to explore these topics.

Each bubble's position at the intersection of a topic and an empirical study type is indicative of the SWEBOK area it relates to, as represented by the color coding detailed in the legend. The size of the bubbles reflects the number of studies corresponding to each intersection point, offering a visual representation of the volume of research concentrated on particular aspects of gender diversity within the specified SWEBOK areas. This visualization, therefore, acts as both a summary of current research trends and a directive for future studies to address less explored areas within the domain of gender diversity in software engineering. The topic of “General recognition” using data mining shows a significant contribution of various areas including 'Software Engineering Professional Practice', 'Software Construction' and all areas.

Additionally, the topic of "Contribution to OSS" using data mining within the 'Software Engineering Professional Practice', 'Software Construction', Quality and 'Mixed', domain receive a significant emphasis as well. This suggests a strong research interest in the open-source software community concerning software practices. Conversely, areas such as "Requirements" and "Quality" exhibit fewer studies, often just one, indicating these topics are less explored and could benefit from increased academic attention to diversify understanding in these aspects of software engineering. Overall, this visualization is instrumental in showcasing the current focal points and gaps within the field, providing a clear roadmap for future research directions

5. CONCLUSION

This paper provides an encompassing view of gender diversity in the field of software engineering. Following the rigorous guidelines established by Kitchenham et al. [10], its investigation formulates seven research questions and culminates in an in-depth analysis and synthesis of selected studies from an initial pool of 1747 potential papers.

The review revealed a shifting focus of the research community towards gender diversity which indicates the growing recognition of gender diversity as a critical aspect of software engineering. It observed that contributions to Open-Source Software (OSS) dominate the topic landscape, signaling the importance of gender diversity in community-driven development environments. Although, its findings underscore a gap in the literature regarding the unique challenges men face in the field, presenting an opportunity for future exploration to attain a comprehensive understanding of gender diversity within software engineering.

In this research, the systematic mapping review has demonstrated that while considerable steps have been made in understanding the role of gender within software engineering, there is still much ground to cover. The prevalence of 'non-inclusive communication' and 'Toxic culture' as challenges indicates continuing issues that hinder the creation of inclusive and supportive environments for all genders. Furthermore, the recognition of 'Impostor syndrome' and 'Lack of peer parity' lights internal and external barriers to gender equality within professional contexts. This systematic mapping review not only synthesizes existing research but also identifies crucial areas for further investigation.

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