Do Gender Representations Influence Contributions and Collaborations in Software Systems Research? An Exploratory Study

Abstract—**Software system research is a field where diverse perspectives are essential for innovation and the development of user-centered solutions. Despite this, a significant gender disparity persists, with women being underrepresented. Existing studies investigated the overall statistics on gender representation in the software engineering industries, conference program committees, and conference participants. However, the extent of women's involvement in research studies, specifically their contributions and collaboration dynamics, has not been thoroughly investigated. To address this gap, we analyzed 384 Journal of Systems and Software (JSS) articles with contributions from both male and female authors, using the 14-role CRedit authorship contribution statement (CRedit) taxonomy to evaluate individual contributions. First, we analyzed the prevalence of women and found that only 32.74% of women contributed to these studies, with female-led studies and female-supervised studies being comparatively lower than males. Second, we investigated female authors' contributions in terms of the CRedit roles. Female authors contribute similarly across most CRedit roles, with particularly high contributions in conceptualization, writing, and reviewing the article. Third, we investigated the key areas where female authors are contributing more. Women are more engaged in human-centric research areas, reflecting their focus on user-oriented studies. Finally, we examined collaboration patterns in leadership and supervisory roles, finding that female-supervised studies had 20% more local collaborations compared to national collaborations. Overall, our findings highlight the significant contributions of female authors across various research roles, showcasing their growing presence and impact in software system research. However, the findings also indicate areas where greater inclusion and recognition are needed to achieve a more balanced representation in the field.**

Index Terms—**diversity, female authors, software system research, CRedit**

I. Introduction

Diversity boosts innovation when actively maintained and protected from stereotypes [1]–[3]. Research shows that gender-diverse teams are more efficient and bring together unique ideas, which is important for creating robust, user-centered software systems [4]–[6]. Consequently, there are ongoing efforts to build more equitable, diverse, and inclusive teams in the technology sector [7]–[9]. However, despite these efforts, the gender gap in computer science is significant [10], [11] and even more pronounced in software engineering, where diverse perspectives could directly improve the usability and functionality of complex systems. The UNESCO 2023 report noted that, as of 2020, women made up only 31% of researchers in science and engineering [12]. Moreover, women's research contribution is confined to specific regions [13]. This persistent underrepresentation of women in software research contributes to biased software design [14], negative gender stereotypes [15] and reduced mentorship opportunities [16]. Therefore, a comprehensive study is necessary to (a) investigate whether women are underrepresented due to limited contribution to research, (b) understand their prevalence in the key areas of software system research, and (c) comprehend whether they have restricted access to collaboration and leadership opportunities.

Researchers are increasingly interested in understanding whether gender gaps are similar in both academia and industry. While several studies have conducted research to find out the gender disparity in the industry [17]–[19], few diversity-related studies have been conducted in the software system research area [20]–[24]. For example, Cavero et al. [24] found that women's participation increased at a rate of 3.5% annually from 1960 to 2010, though this growth was primarily driven by the Human-Computer Interaction (HCI) field. On the other hand, Mathew et al. [25] found that women are underrepresented in the top most cited articles in the field of software engineering. Notably, Felizardo et al. [13] found that research contributions from women in the software engineering field have globally increased over the years but are still concentrated in European countries. While these studies provide valuable statistics on gender representation, they do not directly address whether women's underrepresentation is due to their lack of contribution or whether women are contributing at lower rates compared to men. Furthermore, the extent of women's involvement in research studies, their collaboration dynamics, and the significance of their leadership roles may influence in lowering their overall representation.

In this study, we conduct an empirical study to a) investigate women's participation and leadership in software system research, b) analyze their commitment and contribution to the research work, c) identify their specialization and interest in the specific area of software system research, and d) explore their collaboration dynamics at local, national, and international levels, particularly when a woman is leading or supervising the research. First, we selected 2000 articles from JSS. After filtration, we extracted and recorded the authors' information from each article. Then, we manually labeled their individual contribution ratio and identified the study areas where female leadership and supervision are more noticeable. Next, we explored their collaboration dynamics in various aspects. In particular, we answered four research questions and made four major contributions.

RQ$_1$(*participation and leadership*)**: What percentage of software systems articles have female author(s), and how often are they the lead authors?** We aim to assess the prevalence of female authorship and leadership (i.e., lead author role and supervision role), which is essential for understanding the overall gender representation in software system research.

RQ$_2$(*commitment and contribution*)**: What are the most common contributions by female authors to various aspects of research projects in software systems?** We attempt to identify the primary contributions of female authors, which can help to highlight their roles and impact within software systems research.

RQ$_3$*(specialization and interest)***: Can we identify the specific areas of software systems research where female leadership and contributions are most prominent?** We examine areas with strong female leadership and contributions to provide insight into the research subdomains where women are thriving.

RQ$_4$*(collaboration dynamics)***: Do female authors in software systems research collaborate more within their organization, nationally or internationally?** We aim to understand the collaboration patterns of female authors, which is crucial to reveal their networking reach and engagement levels in software system research.

II. Background

A. CRedit details

To analyze the gender-based contribution, we focused on studies that included the *CRedit authorship contribution statement* section (or "CRedit section" for short). The Contributor Role Taxonomy was developed after realizing that simple-ordered author lists do not show the different types of contributions researchers make [26], [27]. Therefore, a 14-role taxonomy was introduced to represent contributions more accurately, and it has been in use since 2015 [28]. Table I summarizes the CRedit role taxonomy.

III. Methodology

Fig. 1 shows the schematic diagram of our study methodology.

A. Dataset Construction

We collected 2,000 JSS articles from 2015 to 2024. JSS is one of the leading journals dedicated to software systems research, established in 1979. According to Google Scholar, the journal has an h5-index of 69, which ranks third among international publication venues in software systems [29]. We filtered the collected articles based on the availability of the CRedit section. Table II shows the breakdown of articles with and without the CRedit section. As shown in Table III, we found 763 articles with the CRedit section. Of these, only 399 articles have one or multiple female authors and among the 399 articles, 15 articles had only female authors. To analyze the collaboration pattern of both male and female authors, we discarded these 15 studies and finalized 384 articles for our further investigation.

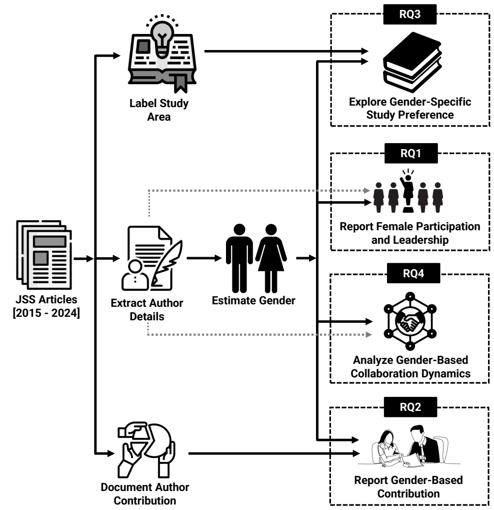


Fig. 1: Study methodology

B. Analyzing the prevalence of the authors

First, we recorded each author's name and affiliation for every article. Next, we identified the authors' genders by reviewing the biographies provided at the end of each article. We then analyzed the prevalence of male and female authors and looked at their leadership and supervisory roles. Specifically, if a female author was listed first, we labeled it as a female-led study; if a female author held a supervisory role, we labeled it as a female-supervised study, and we applied the same approach for male-led and male-supervised studies. However, to examine the collaboration dynamics for male and female authors in **RQ$_4$**, we focused on studies with only one gender in the supervisory role. Out of 384 studies, we found that 163 articles had both male and female supervisors, while 221 articles had either a female or male supervisor (45 female-supervised and 176 male-supervised). To focus on how collaboration dynamics change based on a single-gender supervisor, we excluded those 163 articles with both male and female supervisors.

C. Analyzing commitment and contribution of the authors

We analyzed the CRediT section in each article to identify the roles contributed by each author. There are 14 different roles an author could contribute to (See Table I) in each paper. For example, if an author participated in *Conceptualization (C1)*, we assigned 1 to indicate their contribution; if they did not participate, we assigned a 0. Specifically, we calculated the contribution ratios for male and female authors by taking the number of male or female authors who contributed to a role and dividing it by the total number of male or female authors in each paper.

For a given paper, P_i, where $i = 1, 2, 3, ..., K$ and K is the total number of papers, if M_i represents the number of male contributors for a specific role and M_K represents the total

TABLE I
Contributor Roles Taxonomy Details [26], [27]

ID	Contribution	Description
C1	Conceptualization	Refining the core ideas, establishing the research objectives, and outlining the overall direction or goals of the study.
C2	Data Curation	Managing activities to produce metadata, scrubbing data, and maintaining research data for initial use and later re-use.
C3	Formal analysis	Applying statistical, mathematical, computational or other formal techniques to investigate study data.
C4	Funding acquisition	Securing financial support for the project leading to this publication.
C5	Investigation	Carrying out research and investigation, specifically performing experiments or collecting data/evidence.
C6	Methodology	Developing or designing the methodology and creating models.
C7	Project administration	Managing and coordinating the planning and execution of research activities.
C8	Resources	Providing study materials, reagents, samples, patients, laboratory samples, animals, instruments, computing resources or other analytical tools.
C9	Software	Programming and software development, including designing programs, implementing code and algorithms, and testing existing code components.
C10	Supervision	Providing oversight and leadership for research planning and execution, including mentorship outside the core team.
C11	Validation	Verifying the replication and reproducibility of results, experiments, and other research outputs, either as part of the activity or as a separate process.
C12	Visualization	Preparing, creating, and presenting the published work, with a focus on visualization and data presentation.
C13	Writing - original draft	Preparing, creating, and presenting the published work, specifically by writing the initial draft, including any substantive translation.
C14	Writing - review & editing	Preparing, creating, and presenting the published work by original research group member, specifically through critical review, commentary, or revisions, including pre- and post-publication stages.

TABLE II: Data Statistic

Year	Total articles	# of articles with CRedit
2015	181	0
2016	228	0
2017	207	0
2018	207	0
2019	174	0
2020	182	96
2021	159	123
2022	182	116
2023	236	197
2024	244	227

TABLE III: Data Criteria

Criteria	# of articles
Number of Articles (2015-2024	2000
Articles with CRedit section	763
Articles with female contribution	399
Articles with only female authors	15
Articles that have both male & female contribution	384

number of male authors in the paper, the male contribution ratio CR_{male} for that role is given by:

$$CR_{male} = \frac{M_i}{M_K}$$

Similarly, for female contributors, if F_i represents the number of female contributors in a specific role and F_K is the total number of female authors in the paper, the female contribution ratio CR_{female} for that role is:

$$CR_{female} = \frac{F_i}{F_K}$$

For example, if a paper has a total of two female authors and five male authors, one out of two female authors has contributed in a particular role, and two out of five male authors participated in that role, then the female contribution ratio is $CR_{female} = \frac{F_1}{F_2} = \frac{1}{2} = 0.50$ and the male contribution ratio is $CR_{male} = \frac{M_2}{M_5} = \frac{2}{5} = 0.40$. Then we analyzed the quartiles of these contribution ratios by creating box plots to visualize the distribution of contributions.

D. Identify key areas of software systems with authors' leadership and contribution

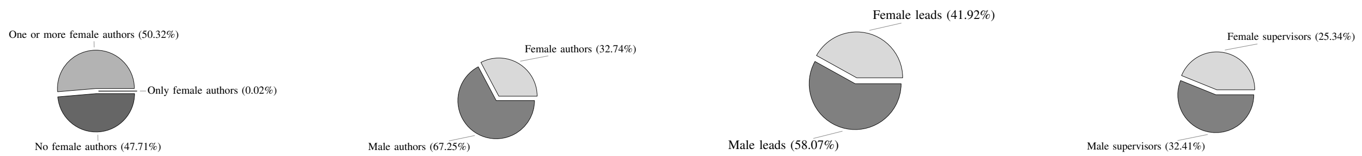
We used open coding to manually identify the subdomains of SE where female contribution and leadership are more prominent and those where they are less present. To achieve this, we compiled a set of 384 research articles that feature at least one female author.

The first two authors collaboratively labeled each selected article based on its title, abstract, and keywords. Together, they used open codes that reflect the study's focus. For example, they categorized the study by Zhu et al. [30] using labels like "testing techniques" and "code quality and maintenance" because the study closely concentrated on these areas. To be specific, the study aimed to offer guidelines for developers to help them make informed software maintenance decisions when faced with low mutation test scores. Similarly, we labeled all 384 articles manually, and when disagreements arose during coding, we discussed the issues until we reached a consensus.

Consequently, a coding book was developed that included 107 labels. These labels were then organized into broader categories. For example, labels like "AI Safety and Ethics," "AI in Testing and Bug Detection," and "AI in Development Tools" were grouped under the main area of "Applied AI in Software Engineering." This approach is similar to the one used by Sagdic et al. [31]. As a result, we identified a total of 23 subdomains within software systems.

After our initial round of coding, we identified that software system research in the JSS can be categorized into 13 subdomains[1], which closely resemble those in our codebook. To align with their framework, we first merged several of our subdomains and subsequently renamed them. For instance, the JSS subdomain titled "Methods and tools for software requirements, design, architecture, verification and validation, testing, maintenance, and evolution" is quite broad. We combined our three main subdomains—"Software Architecture and Design," "Software Quality and Testing," and "Software Maintenance and Evolution"—into this single category. This approach of integrating our identified subdomains with JSS's established subdomains ensures that our categorization is closely aligned with the journal's focus and accurately represents the recognized areas within software system research.

[1]https://www.sciencedirect.com/journal/journal-of-systems-and-software/about/aims-and-scope



(a) Ratio of publications with one or more female authors, only female authors, and no female authors

(b) Ratio of total female and male authors in female-contributed articles

(c) Ratio of female-led and male-led studies

(d) Ratio of female-supervised and male-supervised studies

Fig. 2: Comparison of different ratios across publications and author roles

E. Exploring the collaboration dynamics of the authors in software system research

We recorded each author's country and institution based on their affiliations to see whether the study involved local, national, or international collaboration. If all authors were from the same institution, we labeled it as a *local collaboration*. When the authors are from the same country but different institutions, we labeled it as a *national collaboration*. However, when the authors are from different countries, we labeled it as *international collaboration*. We measured the collaboration patterns across all articles. Then, we looked specifically at studies led or supervised by female authors and compared these patterns with those led or supervised by males. Additionally, we checked whether the institutions were academic or industrial to gain more insights into the nature of these collaborations.

IV. Study Findings

A. Participation and Leadership of women in Software System Research (RQ$_1$)

This section summarizes the participation, leadership, and supervision skills of women in software system research. As shown in Fig 2a, half of the articles (399 out of 763) have one or multiple female authors, whereas 47.71% (364 out of 763) articles have no female authors at all, and a very lower number of articles (15 out of 763) have only female authors. While a slight majority of articles feature female involvement, the fact that nearly half of the studies lack female participation points to a steady imbalance. To further examine gender representation, we analyzed 384 articles (as described in Section III-A) with both male and female authors. Fig. 2b illustrates a low presence of females in software system research. Out of 1,771 total authors in 384 articles, only 580 authors are female, and 1,191 authors are male. This lower representation of women might extend into roles with greater influence, such as leadership and supervision.

To investigate this, we analyzed the prevalence of women in leadership and supervisory roles. Fig. 2c shows that while female-led studies account for a significant portion (41.92%), they are still outnumbered by male-led studies, which constitute 58.07%. Similarly, Fig. 2d highlights that female authors are underrepresented in supervisory roles, with their participation nearly 8% lower than that of male authors. This lower representation of women in leadership roles may be influenced by factors such as males perceiving that female leaders are less effective than their male counterparts [32]. Such underrepresentation could hinder mentorship opportunities and career development for female researchers.

Summary of RQ$_1$: Over 47% of studies lack female authors, and the overall ratio of female authors remains low. Although over 40% of studies have female authors in lead positions, the presence of female authors is below 30% in supervisory positions.

B. Female authors commitments and contributions (RQ$_2$)

The previous section highlighted the overall prevalence of women's participation in software system research. This section analyzes their involvement across various contributory roles. Fig. 3 illustrates notable patterns in female authors' involvement in contribution roles. We excluded the funding acquisition and resources roles from the figure as participation from both male and female authors in these roles is minimal for quartile analysis. Specifically, 343 out of 384 studies had no female authors contributing to funding acquisition, and 312 out of 384 studies had no female authors involved in resource-related tasks. Similarly, 278 studies lacked male contributors in funding acquisition, and 297 studies had no male authors in the resources role. This suggests that both male and female authors contribute very little to funding and resource management tasks, with these roles mostly handled by very few individuals considered outliers (Section III-C).

For the rest of the contributory roles, our analysis reveals that female authors are contributing almost equally in formal analysis, investigation and methodology roles with males. However, their contributions are notable, particularly in conceptualization, writing the original draft, and reviewing it. For example, in at least half of the research articles, 78% of female authors participated in conceptualization compared to male authors (50%). Similarly, in the role of writing and reviewing the original draft, female authors are ahead of male authors. From 50% to 100% of female authors and from 40% to 75% of male authors are contributing in at least half of the articles. This finding can also be supported by a study based on top economics journals by Hengel [33], which found that female

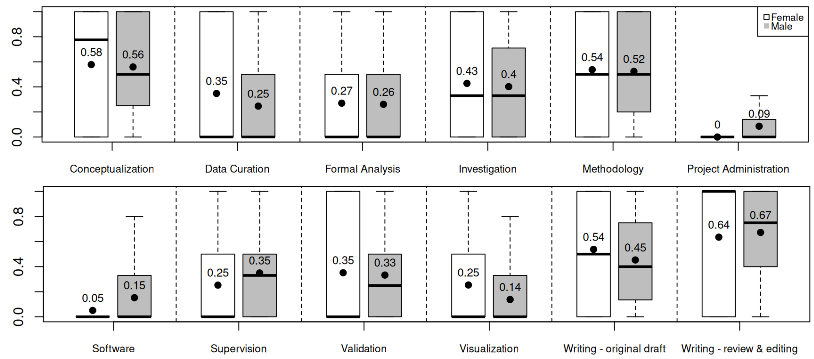


Fig. 3: Contribution Ratio

economists often excel in writing clarity, surpassing men in that area.

On the contrary, female participation sharply declines in supervision and validation roles. In at least half of the articles, female authors did not contribute to either of these roles at all, while male authors contributed in supervision and validation roles at rates of 33% and 25%, respectively. Lindahl et al. [34] found that men often produce more research output than women during and after doctoral studies. Since women are less often involved in supervision and validation, they may have fewer chances to co-author with senior researchers and build strong networks. However, female authors also contribute in a relatively balanced way with male authors in data curation, project administration, software, and visualization roles, with average contributions ranging from 0.05 to 0.35 compared to male authors' range of 0.09 to 0.35.

Summary of RQ$_2$: The results indicate that female authors contribute almost equally in formal analysis, investigation, and methodology, excelling in conceptualization, writing, and reviewing. However, their contributions are less recognized in supervision and validation. Additionally, female authors show a relatively balanced involvement with male authors in data curation, project administration, software, and visualization roles.

C. Female Leadership and Contribution Across Key Areas (RQ$_3$)

In the previous RQ, we found that women contribute nearly as much as men in various roles within articles related to software systems. In this section, we analyze the broader context to explore the research domains of these articles, focusing on where female researchers are more or less involved than their male counterparts. A quantitative comparison in Table 4 shows that men-led studies outnumber women in the key areas of AI, data analytics, and big data in SE (*S5*). Specifically, 22.4% of men-led studies were in *S5*, while only 12.4% of women-led studies fell into this category. Furthermore, our Chi-Square analysis also yielded a surprising outcome—a statistically significant disparity ($p = 0.018$) specifically within the subdomain of *S5*. Interestingly, no other major areas in software system research exhibited such a gender-based difference. This trend is concerning; first-authored studies by women in AI for SE are significantly lower than those by men, highlighting the scarcity of female leadership in the most progressive sector of SE.

Conversely, we found that women are leading the majority of research in the key area of human factors and management in software development (*S4*), with 33.3% under female supervision compared to just 10.8% for male supervision. Furthermore, we have identified a statistically substantial difference ($p = 0.0005$), specifically in the *S4* subdomain. Once again, no other major areas in software systems exhibit such a significant gender-based difference in supervision. Cavero et al. [24] also found that women are indeed more engaged in human-centered areas of computer science, and this pattern seems to extend into research on software systems. This trend may stem from historical perceptions that women are more skilled in "people-oriented" roles [35], [36], which may have influenced their research choices toward human-centric studies rather than technical fields like AI.

Summary of RQ$_3$: The results show that female first authors are less common than male authors in the field of AI in software engineering. However, female faculty supervise research on the human aspects of software more often than their male counterparts, suggesting that while men focus on technical advancements, women contribute more to understanding the social implications of these technologies.

D. Collaboration dynamics of women in Software System Research (RQ$_4$)

Previously we found that women are underrepresented in the leading and supervisory roles. Moreover, despite their underrepresentation, they have significant involvement in the contributory roles. Therefore, we further attempted to explore how female authors can influence different collaboration patterns, especially when they are in the lead or supervisory position.

TABLE IV: Gender-Based Leadership and Supervision of Articles in Key Areas of Software Systems Research

ID	Key Areas	Female Led (*out of 161 papers*)	Male Led (*out of 223 papers*)	Female Sup (*out of 45 papers*)	Male Sup (*out of 176 papers*)
S1	Methods and tools for software requirements, design, architecture, verification and validation, testing, maintenance and evolution	38 (23.6%)	64 (28.7%)	9 (20.0%)	46 (26.1%)
S2	Agile, model-driven, service-oriented, open source and global software development	8 (5.0%)	10 (4.5%)	0 (0%)	13 (7.4%)
S3	Approaches for cloud/fog/edge computing and virtualized systems	11 (6.8%)	6.3	4.4	5.1
S4	Human factors and management concerns of software development	28 (17.4%)	13	33.3	10.8
S5	Artificial Intelligence, data analytics and big data applied in software engineering	20 (12.4%)	22.4	15.6	23.9
S6	Metrics and evaluation of software development resources	0 (0%)	0.9	0	0
S7	DevOps, continuous integration, build and test automation	5 (3.1%)	0.4	2.2	1.7
S8	Business and economic aspects of software development processes	3 (1.9%)	1.3	0	0.6
S9	Software Engineering education	7 (4.3%)	2.7	6.7	1.1
S10	Ethical/societal aspects of Software Engineering	3 (1.9%)	0.4	0	0.6
S11	Software Engineering for AI systems	3 (1.9%)	0.9	4.4	1.7
S12	Software Engineering for Sustainability	2 (1.2%)	0	0	0
S13	Methods and tools for empirical software engineering research	33 (20.5%)	18.39	13.3	21.0

At first, in Fig. 4, we explored the overall collaboration pattern for all 384 studies. We found that over 50% (209 out of 384) of the articles have international collaboration. However, local and national collaboration have comparatively balanced ratios ranging from 21% to 24%.

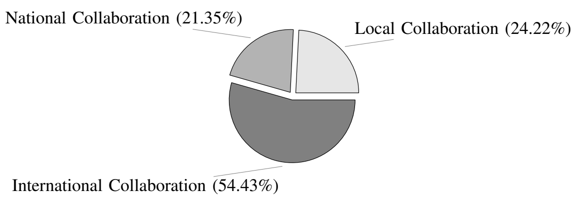


Fig. 4: Collaboration dynamics of all the studies

Next, we investigated the collaboration dynamics when a female author holds the lead or supervisory position and conducted a similar analysis for male authors as well. For investigating the collaboration dynamic in the supervisory positions, we focused on studies where either a female or a male was in a supervisory position (as mentioned in Section, III-B).

Fig. 5, and Fig. 6 show that both female-led and male-led studies prioritize international collaboration ranging from 53% to 55%. However, slightly notable differences exist in the local and national collaboration. Female-led studies show 6% more national collaboration but 5% less local collaboration compared to male-led studies. Similarly, Fig. 7 and Fig. 8 show that both female and male-supervised studies heavily emphasize international collaborations. However, unlike female-led studies, female-supervised studies have a notably higher ratio of local collaboration (33.33%), with a 20% difference over national collaboration (13.33%). In contrast, male-supervised studies maintain a more balanced distribution between local and national collaborations (up to 25%).

The higher difference in local collaboration for female-supervised studies may be attributed to the tendency of female supervisors to prioritize local collaborations, likely due to strong connections within their immediate academic or professional communities. In contrast, female lead authors seem to favor national collaborations slightly more, possibly because they are relatively new to the profession and seek to connect with researchers in similar fields to expand their networks. However, female supervisors seem less willing to conduct national collaborations, potentially because their research domains may not align with those of other lab supervisors at the national level.

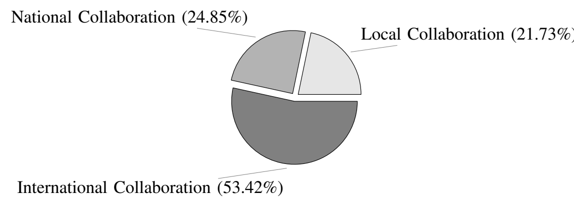


Fig. 5: Collaboration dynamics of female-led studies

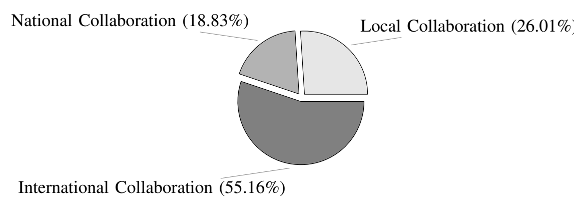


Fig. 6: Collaboration dynamics of male-led studies

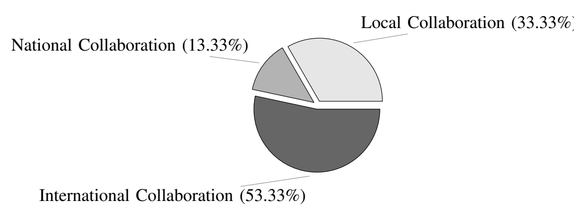


Fig. 7: Collaboration dynamics of female-supervised studies

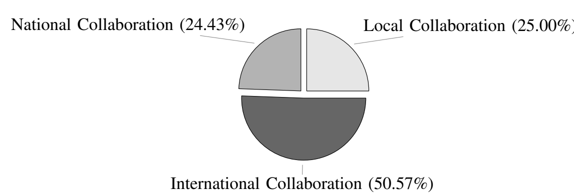


Fig. 8: Collaboration dynamics of male-supervised studies

Lastly, we examined collaboration types at the industrial and academic levels. Both female-led and female-supervised

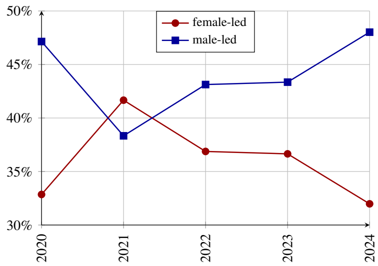


Fig. 9: Female-led and male-led studies over the last 5 years

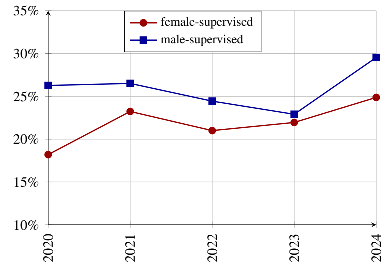


Fig. 10: Female-supervised and male-supervised studies over the last 5 years

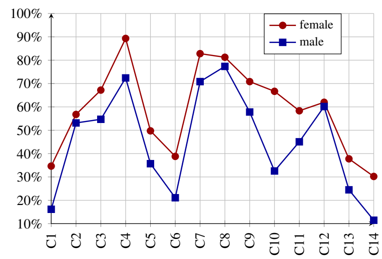


Fig. 11: Ratio of studies where females are not involved in the specific contributions

studies demonstrate similar levels of industrial collaboration, ranging from 25% to 27%. Interestingly, male-led and male-supervised studies follow a similar trend, showing a consistent engagement in industry collaboration. This similarity across both female and male leadership types highlights a consistent preference for industrial partnership, regardless of gender.

Summary of RQ$_4$: Both female-led and female-supervised studies prioritized international collaborations. Male-led and male-supervised studies had a balanced mix of local and national collaborations, while female-supervised studies showed 20% more local than national collaboration. No significant differences were found in industrial versus academic collaborations across all study types.

V. Key Findings

In this section, we discuss the key findings of this study.

Fading Women, Rising Disparity. Our studies found that over 47% (364 out of 763) of studies do not have any female authors at all (Section IV-A). Even in those studies, female participants are significantly low. While female-led studies have a higher ratio (41.92%) than female-supervised studies (25.34%), Fig. 9 shows that female-led studies have been declining over the past five years. After reaching its highest point at 53.33% in 2021, the percentage of female-led studies has steadily declined through 2024. Conversely, female-supervised studies (Fig. 10) have gradually increased, but their ratio is still lower than male-supervised studies. Even when male-supervised studies were at their lowest in 2023, female-supervised studies did not reach a similarly high level. These findings align with research by Kohl et al. [37], which highlights the challenges women face in software engineering management roles. Women in leadership roles often feel they must work harder than their male peers to gain the same level of recognition. There is a perception that when men perform the same work, it is praised, whereas when women do it, it is viewed with question, highlighting the additional pressures women face in these roles.

Women in Software Systems Research: Still Undervalued. Our study found that out of 14 contributory roles, women are involved equally or similarly in most of the roles (Section IV-B). Moreover, their contribution is significantly higher in outlining the study objective and preparing the manuscript. However, as shown in Fig. 11, the number of studies where women had no contribution to a specific role is consistently lower than that of men. The lower rate of contribution by women in software system research teams may stem from their undervaluation within these groups. Research indicates that women often face challenges such as gender bias, lack of recognition, and limited access to leadership opportunities, which can hinder their active participation and contribution. For instance, a study by Guzmán [38] highlights that women in the software industry frequently encounter socio-cultural challenges that discourage their involvement, leading to feelings of isolation and undervaluation.

VI. Existing Work

Several studies have been conducted to analyze diversity in the context of software engineering research [9], [13], [20]–[23], [39]–[41]. Studies reveal a gradual increase in women's participation in computing research, though disparities persist. For instance, Cavero et al. [20] reported a 3.5% annual growth in women's involvement in computing research from 1960 to 2010, with significant activity in Human-Computer Interaction. Boekhout et al. [21] highlighted an increase in women starting research careers (from 33% in 2000 to 40% recently), though men still produce 15-20% more publications and dominate senior authorship roles. Felizardo et al. [13] observed a global increase in women's research contributions to the software engineering field over the years, though these contributions remain predominantly concentrated in European countries. However, Hosseini et al. [41] observed fewer publications, citations, and international collaborations for female researchers at Dublin City University from 2013–2018. Frachtenberg and Kaner [42] also found a significant gender gap in computer systems research, with women making up only 10% of researchers based on an analysis of 53 peer-reviewed systems conferences from 2017. Similarly, Mathew et al. [25] found that women are underrepresented in the top-most cited papers in the software engineering field.

Moreover, the lack of diversity in Artificial Intelligence (AI) research remains a pressing concern. Freire et al. [43] found that women are more likely to participate in organizing committees than as authors. To monitor diversity in the AI research community, the *divinAI* project, launched in 2019, highlighted the low representation of women in AI [44]. Even when women engage in AI research, Stathoulopoulos and Mateos-Garcia [45] found that many tend to focus on societal issues—such as ethics, social impact, and policy—rather than purely technical domains.

Despite these insights, there remains a critical research gap in understanding the specific contributions of female authors in software system research. While diversity-related studies have explored broader trends and challenges, few have analyzed how women contribute to different roles of research within this field. Moreover, the impact of collaboration dynamics, particularly when research is led or supervised by female authors, has not been thoroughly investigated. Our study addresses this gap by providing detailed insights into the contributions of women in software system research and exploring how gender influences collaboration and leadership dynamics in this domain.

VII. Threats to Validity

Threats to external validity relate to the generalizability of our findings. We focus specifically on software systems research, with JSS being one of the leading journals in this domain. While other journals also publish articles related to software systems alongside other areas, they often lack a dedicated section highlighting contributions. By analyzing all articles published in JSS since the introduction of CRediT, we ensured comprehensive coverage for this journal. However, our conclusions may not apply to research in other fields, where author contributions might be recorded differently.

Threats to internal validity relate to experimental errors and biases. include potential inaccuracies in gender prediction. We recognize that our manually categorizing key areas in SE could be subjective. To address this effectively, the first two authors collaborated to code each article, grouping these codes into common themes and discussing disagreements. After our inductive coding, we aligned our themes with established key areas from the JSS to ensure consistency with recognized SE domains.

Another challenge to internal validity is the use of a binary approach to gender detection. We relied on the biographies where no mention of genders beyond male and female was found. Identifying additional gender identities would require direct input from the authors, which was beyond the scope of this study. We acknowledge this limitation and suggest that future studies use more inclusive methods that recognize non-binary and other gender identities for a broader and more accurate analysis.

VIII. Conclusion

This study examines the prevalence, leadership roles, contributions, and collaboration dynamics of women in software system research. Analyzing 384 JSS articles with the CRedit taxonomy, we found that nearly 48% of the studies lacked female authors entirely, underscoring a persistent underrepresentation of women in the field. While female-led studies made up 41.92% of the total, their prevalence has steadily declined over the past five years. In contrast, female-supervised studies have shown gradual growth, though they continue to fall behind male-supervised studies in numbers. Women made significant contributions in areas such as conceptualization, writing, and reviewing, with nearly equal participation in other roles; however, their involvement in supervisory and validation roles remains comparatively low. Female-led studies were notably less prevalent than male-led studies in AI-focused research, while female-supervised studies were more prominent in human-centric domains. Collaboration patterns also differed, with female-supervised studies favoring local collaborations, whereas female-led studies showed a slightly higher preference for national collaborations. These findings highlight structural and societal biases that influence the opportunities available to women in leadership roles, emphasizing the need for targeted efforts to address these disparities and promote greater gender equity in software system research.

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