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Beyond Team Composition: An Empirical Analysis of Gender-Based Role Distribution in Student Software Development Projects

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ABSTRACT

Gender imbalance continues to be a persistent challenge in software engineering education and professional practice. While extensive research has examined women's underrepresentation in enrollment and workforce participation, comparatively less attention has been given to how responsibilities and roles are distributed within student software development teams. Role allocation during education is particularly important, as early experiences can influence confidence, skill development, and long-term career choices in software engineering. This study presents a cross-sectional empirical investigation into gender-based role distribution in student software development teams operating within a project-based learning environment.
The analysis is based on data collected from 628 students, including 183 women, organized into 85 software development teams over a seven-year period. Quantitative data were extracted from final project reports and analyzed using binary and multinomial logistic regression techniques. The study examines three key aspects: the influence of team gender composition on women's participation in highly technical roles, the impact of female leadership on role allocation, and the evolution of women's role distribution across student cohorts.
The results indicate that women are significantly less likely than men to occupy highly specialized technical roles, regardless of the gender ratio within teams. Contrary to expectations, the presence of a woman in a leadership position does not increase the likelihood of women assuming highly technical responsibilities. However, the findings reveal a gradual diversification of roles among women over time, particularly in leadership and coordination-oriented positions. These outcomes suggest that structural and cultural factors, rather than numerical representation alone, shape role selection in student teams. The study contributes empirical evidence to gender-focused software engineering research and provides actionable insights for designing more inclusive educational environments that promote equitable role exploration and sustained engagement in technical careers.

Keywords:- Software Engineering Education, Gender Diversity, Team Roles, Leadership

1. INTRODUCTION

The underrepresentation of women in software engineering remains a critical issue across both academic and industrial contexts. Despite ongoing efforts to increase female enrollment in computing-related programs, disparities persist not only in participation rates but also in the nature of roles women assume within software development teams. Educational settings play a foundational role in shaping students' professional identities, confidence, and career trajectories. Consequently, understanding gender dynamics in student teams is essential for fostering inclusive learning environments and long-term retention in the field.

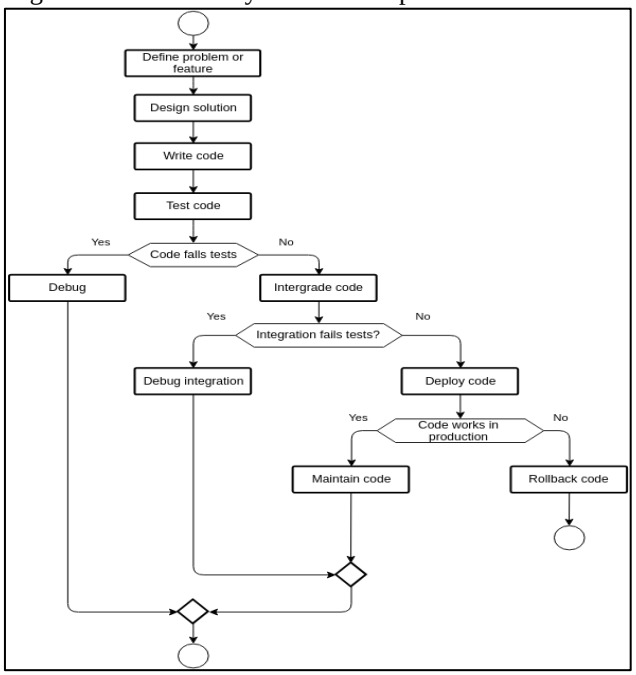
Project-based learning is widely adopted in software engineering education, requiring students to collaborate in teams that mirror professional development practices. Within these teams, responsibilities are often distributed across a range of technical, managerial, and coordination roles. Prior studies suggest that women tend to gravitate toward or are steered into roles that emphasize organization, communication, and coordination, while men more frequently occupy highly specialized technical positions. Such patterns, if reinforced during education, may contribute to persistent gender inequalities in the software engineering workforce.

This study aims to deepen the understanding of gender-based role distribution within student software development teams. Specifically, it investigates whether team gender composition influences women's likelihood of assuming technical roles, whether female leadership affects role allocation, and how women's participation in different roles evolves over time. By addressing these questions, the study seeks to inform educational practices that support equitable participation and skill development for all students.

2. METHODOLOGY

This research adopts a cross-sectional empirical design based on data collected from a long-running project-based software engineering course. The dataset comprises information from 628 students distributed across 85 development teams over seven academic years. Each team worked on a real-world software project, completing all major phases of the development lifecycle, including requirements analysis, design, implementation, testing, and evaluation.

Data were extracted from final project reports submitted by each team at the end of the course. These reports documented team composition, individual roles, and project outcomes. For the purpose of analysis, roles were categorized into three levels based on their technical intensity: highly technical roles, less technical roles, and non-technical roles. This categorization enabled systematic comparison of role allocation across gender groups.



Several variables were constructed for statistical analysis, including gender, team gender ratio, presence of a woman in a leadership role, year of participation, and role classification. Binary logistic regression was employed to assess the likelihood of students occupying highly technical roles, while multinomial logistic regression was used to examine variations in role diversity across cohorts. These methods allowed for robust testing of relationships between gender-related factors and role distribution patterns.

2.1 Study Context and Dataset

The dataset comprises information collected from 628 students, including 183 women, organized into 85 software development teams over a period of seven academic years (2017–2023). Each team consisted of five to eight students and was responsible for delivering a complete software solution for an external customer. The projects covered all major phases of the software development lifecycle, including requirements analysis, system design, implementation, testing, documentation, and final presentation.

Data were extracted from the final project reports submitted by each team as part of course assessment. These reports provided structured documentation of team composition, assigned roles, technical responsibilities, and project outcomes. Ethical approval was obtained prior to data collection, and all data were analyzed in anonymized form.

2.2 Role Classification and Variable Definition

To enable systematic analysis, the wide variety of roles reported by students were categorized based on their level of technical specialization. Drawing on established software engineering literature and industry role definitions, roles were grouped into three categories:

- Highly technical roles, involving core software construction activities such as system architecture, backend development, security, and advanced programming tasks
- Less technical roles, combining technical awareness with coordination or quality-focused responsibilities

- Non-technical roles, primarily centered on documentation, organization, and stakeholder communication

Several variables were constructed for statistical analysis, including gender, team gender ratio, presence of a woman in a leadership role, year of participation, and role category. This structured categorization allowed for consistent comparison across teams and cohorts while preserving the practical relevance of real-world role assignments.

2.3 Analytical Approach

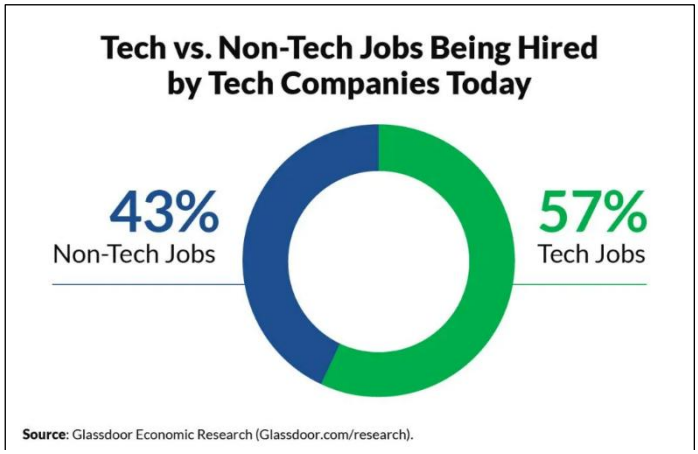
To test the research hypotheses, binary logistic regression was employed to model the likelihood of students assuming highly specialized technical roles. This method is well-suited for examining relationships between categorical outcomes and multiple explanatory variables, including interaction effects. Additionally, multinomial logistic regression was used to analyze variations in role diversity across different student cohorts and to assess longitudinal trends in women's role participation.

By combining these statistical techniques, the methodology enables a robust examination of how gender, leadership, and temporal factors influence role allocation in student software development teams. This approach ensures analytical rigor while maintaining alignment with the educational and organizational realities of software engineering practice.

3. RESULTS AND DISCUSSION

The analysis reveals consistent gender differences in role allocation within student software development teams. Women are significantly less likely than men to assume highly specialized technical roles. Importantly, this disparity persists regardless of the proportion of women within a team, indicating that numerical representation alone does not substantially alter role distribution outcomes.

The influence of leadership was also examined. While women were proportionally well represented in leadership positions, the presence of a woman as team leader did not increase the likelihood of other women occupying highly technical roles. In some cases, women in leadership roles were associated with a lower probability of other women taking on technical responsibilities, suggesting complex and potentially unintended dynamics within team structures.



Over time, however, a positive trend emerges in the diversification of roles undertaken by women. Increased participation in leadership, coordination, and hybrid roles indicates growing engagement across a broader range of responsibilities. This diversification appears to be driven partly by shifts in team practices and declining male participation in certain roles, rather than a substantial increase in women entering highly technical positions.

These findings align with existing literature highlighting structural, cultural, and psychological factors that influence women's role selection in software engineering. The results underscore the need for educational interventions that address implicit biases and actively encourage equitable distribution of both technical and non-technical responsibilities.

4. CONCLUSIONS

This study offers a comprehensive empirical examination of gender-based role distribution within student software development teams, highlighting persistent structural patterns that influence women's participation in technical activities. Despite increased awareness and ongoing efforts to promote gender diversity in computing education, the findings demonstrate that women remain significantly underrepresented in highly specialized technical roles. This disparity persists irrespective of team gender composition, indicating that numerical balance alone is insufficient to overcome deeply rooted norms and expectations surrounding technical expertise.

The analysis further reveals that female leadership, while essential for representation and visibility, does not automatically translate into greater technical role participation for women within teams. This finding challenges commonly held assumptions that leadership representation alone can drive inclusive outcomes and suggests that more nuanced mechanisms are at play. Role allocation appears to be shaped by a complex interaction of confidence, prior experience, peer dynamics, and implicit biases that influence how responsibilities are distributed during collaborative work.

Encouragingly, the study identifies a gradual diversification of roles undertaken by women over time, particularly in leadership, coordination, and hybrid positions that combine technical and managerial responsibilities. This trend reflects a slow but positive shift in participation patterns and indicates that educational environments can evolve toward greater inclusivity when sustained efforts are made. However, the limited growth in women's engagement with core technical roles underscores the need for targeted pedagogical interventions.

From an educational perspective, the findings emphasize the importance of designing learning environments that actively promote equitable access to technical responsibilities. Structured role rotation, explicit encouragement of technical skill development, and early exposure to core programming tasks may help counteract self-selection and stereotype-driven role assignment. Educators and curriculum designers must move beyond enrollment-focused diversity initiatives and address how everyday team practices influence learning outcomes and professional identity formation.

In conclusion, this study contributes meaningful empirical evidence to gender-focused software engineering research by demonstrating that role distribution within student teams is a critical yet often overlooked factor in achieving long-term gender equity. By fostering inclusive role allocation and supporting diverse pathways to technical competence, software engineering education can play a pivotal role in shaping a more balanced and sustainable future workforce. The insights presented in this work provide a foundation for future research aimed at developing intervention strategies and evaluating their effectiveness across diverse educational contexts.

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