

An Exploration of Female Engineering Students' Functional Roles in the Context of First-year Engineering Courses

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Abstract: Engineering profession has been regarded as a male-dominant field because of the low representation of females. With an aim to understand female engineering student's perceived group roles in the context of first-year engineering courses, we explored female students' learning experience in a group project setting in this work-in-progress using Benne and Sheats' functional roles model. Based on our qualitative data, we found that female students performed a range of roles in the group project. In the dimension of task roles, female students usually took the roles of assistants, opinion giver, coordinators and initiator-managers. In the dimension of social roles, females served as harmonizers, followers or gatekeepers. As to the dimension of individual roles, some female students self-reported the feeling of being an outsider in working with a project group. Suggestions were proposed to promote engineering curriculum design and improve female students' learning experience in project-based learning.

Keywords: Female engineering students; Functional roles; Project-based learning

Introduction

Engineering profession has been regarded as a male-dominant field due to the low representation of females, whose percentage was reported as 19.2% in U.S. in 2013^[1]. In China, although female students accounted for 51.74% amongst all undergraduates in 2013^[2], the average percentage of female students in the field of engineering was less than 20%^[3]. For example, in the case of Tsinghua University - one of the top universities in China, the average acceptance rate of female students was only 19.4% in the field of engineering, with the highest percentage 30.77% in chemical engineering, while the lowest, 14 %, in computer-science in 2014^[4]. Some prior studies indicated that the low representation of females in engineering program was closely associated with gender differences observed in students' learning experience, self-efficacy and learning outcomes^{[5][6][7]}. Others, moreover, observed that gender differences in terms of students' self-efficacy, engagement level and performance presented significant challenges to the teaching and learning process in engineering education^[7].

Particular challenges for female students have been observed in the team-working environment of a project-based learning process^[8]. Project-based Teaching, as one of the core teaching methods, has been widely adopted in engineering education because of its effects on improving engineering students' critical competences, such as problem-solving, leadership, intercultural communication, teamwork skills and so on^{[9][10][11]}. Nevertheless, according to Kurt Lewin's (1939) group dynamics theory, a team as a whole would exert pressures on individual members, influence their thoughts, actions and group roles, and also affect team cohesiveness and productivity^[12]. That is to say, in the field of engineering, female students' group roles and learning experience may

be affected by a male-dominated learning group, and the potential benefits that can be gained from project-based learning and collaborative learning may be influenced by the group setting.

Although several researchers have tried to explore female engineering students' performance and experience in collaborative learning and project-based learning, their group roles in this context remain under-investigated. Using a phenomenographic approach, we tried to explore female engineering students' diverse functional roles and how those roles came about in collaborative project-based learning. To be specific, we examined female students' functional roles in the context of an undergraduate course in a leading Chinese university, which was titled *Introduction to Engineering*. The purpose of this study is to gain a rich understanding about female students' learning experience in a group project setting. In this present work, we reported our preliminary results from the analyses of seven interviews. The findings of this study could be used to help female engineering students formulate appropriate learning strategies in project-based learning, and provide suggestions for them to take on suitable roles in group study. Possible strategies to optimize the design of future collaborative learning projects were also proposed.

Literature review

Gender study constitutes an important part in engineering education. As found by previous empirical studies, female engineering students had lower entrance opportunity, lower persistence rate, and lower grades than males, and their self-confidence, satisfaction level, educational engagement and academic performance were also found to be at lower levels than their male peers ^{[5][13]}.

As to the possible causes, Felder's study (1995) pointed to the disparities between students of opposite genders in terms of their personal relationships, goal settings, and personal attitudes toward teacher and peer relationships ^[5]. Other researchers like Wilkinson (1996), Takahira et al. (1998) and Huang et al. (2000) highlighted the factors including self-confidence, previous experience and interest in engineering ^{[13][14][15]}. In addition, according to Stephen (2007), professional achievement and learning experience were also effective factors that may influence female students' persistence in engineering study ^[16].

Moreover, self-efficacy as an important influence factor of females' learning experience and academic achievement has also attracted wide attention from researchers ^[17]. Although female students tend to hold lower confidence in studying engineering at the beginning stage, yet as grade increases, female students would become more confident than males, especially in a competitive environment ^{[6][7]}. Female students have also shown more self-efficacy and confidence in terms of learning methods than male students, regardless of their lower self-efficacy in academic achievement ^{[6][8]}. On the influence factors of students' self-efficacy, Hirsch (2013) concluded that students' interest in engineering, their learning experience and the interactive environment in classroom played significant roles ^[18].

Considering the current challenges faced by female students in their study in engineering, some researchers pointed out that collaborative learning was a helpful strategy to increase female engineering students' self-efficacy and improve their learning outcomes ^{[8][19]}. Collaborative learning appeared to be more attractive to female engineering students than their male peers, as female students believed that face-to-face communication was conducive to their confidence in team product quality ^{[19][20]}.

Despite of the potential benefit on collaborative learning for female students, however, other researchers showed that female students' team performances were not as good as male students ^[21]. Using Eberhardt's team functions as an observational protocol, Laeser (2003) observed students' working processes and learning outcomes in the Engineering Practices Introductory Course Sequence (EPICS) at the Colorado School of Mines. The research showed that the gender composition of a team would impact the interactions within the team and the quality of team performance ^[21]. More specifically, when male students were the majority in a team, the team members were more likely to clarify and set a standard when they interact with each other, and their final reports were regarded as with higher quality than teams with more female students ^[21].

In regard to engineering students' learning experience in project-based learning, Du (2006) also found that female students were usually faced with more difficulties than males and often devoted more efforts ^[22]. Based on this finding, a range of suggestions have been proposed in the previous literature to improve female engineering students' learning outcomes. For example, Du and Kolmos (2007) emphasized the importance of a friendly learning environment in collaborative learning for female engineering students ^[23]; Stein (2014) and Goldschmidt (2016) brought up measures like contextual learning, laboratory projects and teachers' intervention to improve female students' self-confidence, persistence, and learning outcomes ^{[24][25]}.

In this study, we focus on improving female students' learning experience by exploring their functional roles and how these roles were formed in a group project setting in a leading Chinese university. Similar to findings in a western context, female engineering students were reported to have lower college entrance opportunities and employment status than males in Chinese universities ^{[26][27]}. As to the possible causes, low self-efficiency, professional interest, parents' jobs and Chinese traditional culture might be associated with these phenomenon ^{[27][28][29]}. Meng (2009) emphasized the importance of a female-friendly engineering education system with the principle of teaching students in accordance of their aptitude ^[30]. Guan (2016), Li et al. (2010) and Wang et al. (2010) suggested to improve female students' learning experience by increasing more practical learning into curriculum design, inviting more female engineering faculty, and giving more encouragement to female students ^{[31][32][33]}. Nonetheless, little effort was made to explore female engineering students' learning experiences in project-based learning.

In summary, female engineering students have faced multiple challenges in their studies. Although collaborative learning was identified as a potential beneficial strategy for female engineering students, complicated factors still remain to be addressed for female

students to truly thrive in a group setting. Therefore, in the present study, we conducted an in-depth exploration of female engineering students' functional roles in collaborative project-based learning in the context of a Chinese university. Suggestions for improving students' learning experience are proposed accordingly.

Theoretical Framework

In this study, we set out to explore female students' functional roles in a group project setting through a phenomenographic approach and how those roles were framed in the group context. In order to identify the group roles of female engineering students during teamwork processes, we used Benne and Sheats' functional roles model (1948) as the theoretical framework. Benne and Sheats' model classified group functional roles into three categories, namely, task roles, social roles, and individual roles^[34].

The task roles are related to the group goals that are shared by all group members. In other words, the roles in this dimension are performed to facilitate the fulfillment of a common task in group working^[35]. Sample roles in this dimension are presented in Table 1 with succinct descriptions.

Table 1. Sample roles in the dimension of task roles^{[12][34][35]}

Group Role	Description
Task Roles	
Initiator-contributor	Propose new ideas; determine the team tasks and goals; suggest solution; find a new way of organizing the group for the task ahead
Information Seeker	Asks for clarification of suggestions frequently; comply with the authoritative view or facts
Opinion Seeker	Seek practical cases; classify and summarize values pertinent to group task
Information Giver	offer facts or authoritative information based on personal experience
Opinion Giver	State own opinions; give suggestions in group's view
Elaborator	Spell out suggestions with examples; deduce reasons of idea adopted by team
Coordinator	Summarize the relationships among various ideas; pull suggestions together
Orienter	Define positions of group members; point out team direction and goals;
Evaluator-critic	Set standards of group functioning; evaluate practicality, logic and procedure of group discussion.
Energizer	Promote the procedure of team decision; supervise the quality of activities
Procedural Technician	Perform routine tasks like distributing materials and manipulating objects; take technical operation
Recorder	Record suggestion, group decision, product of discussion

Social roles are also called group building and maintenance roles. As the name suggested, roles in this category are related to the group's operation, or in Benne and

Sheats' words, "the functioning of the group", such as members' relationship within a group and the way a group works ^[34]. Group members who play social roles take actions to build or maintain group-centered attitudes, strengthen the cooperation between group members and improve the atmosphere during work ^[34]. Sample roles in the dimension of social roles are presented in Table 2 as follows.

Table 2. Sample roles in the dimension of individual roles ^{[12][34][35]}

Group Role	Description
Social Roles	
Encourager	Show recognition to other's suggestion; praise and encourage team member to rise up ideas, opinion, and suggestions
Harmonizer	Mediate the differences between team members; relieve tension in conflict situations through jesting
Compromiser	Resolve conflict when his ideal is involved; admit his error to offer compromise
Gatekeeper	Communicate with others; facilitating participation of members outside teams
Standard Setter	Express standards for teams; apply standards and evaluate quality of teamwork in group processes
Group-observer and Commentator	Write down various aspects of group process; feed data with proposed interpretations into evaluation procedure
Follower	Serve as audiences in group discussion; follow teams' movement

Individual roles are related with the satisfaction of individual objectives, which is irrelevant to group goals or other members' needs ^[34]. Group members playing these roles may show "individual-centered" performance or exert negative influence on group building and maintenance ^{[34][35]}. Individual roles include eight sub-type roles, which are illustrated in the following table with succinct descriptions.

Table 3. Sample roles in the dimension of task roles ^{[12][34][35]}

Group Role	Description
Individual Roles	
Aggressor	Express disapproval of values; joke aggressively; envy other's contribution
Blocker	Tend to be negativistic; show stubbornly resistant; disagree without reasons; raise issues after the group has bypassed them
Recognition-Seeker	Seek attention to himself in different ways; report personal contributions; act in unusual ways for superior positions
Self-confessor	Seek audience for personal, non-group oriented expression
Playboy	Show cynicism, nonchalance, horseplay, lack of involvement and other "out of field" behaviors

Dominator	Assert authority in groups; give directions authoritatively; interrupt the contributions of others
Help-Seeker	Call forth other's sympathy responses and help; express insecurity, personal confusion or depreciation of himself
Special	Cloak own prejudices in the stereotype for personal benefit

Using this typology as a framework, functional roles that female engineering students take on in group working can be effectively and efficiently detected.

Method

Participants

Purposeful sampling was employed in recruiting female engineering students as interviewees. In order to guarantee the diversity of samples in different contexts, we chose two schools which offered the course of *Introduction of Engineering* in a leading Chinese university H. School A is composed of mainly Chinese students and faculty, while school B is a school that is cooperatively run by University H and another U.S. university Y. Students who satisfied the following two criteria were invited via emails or text messages: (1) they were first-year female engineering students; (2) they took the course of *Introduction of Engineering* in one of these two schools. As a result, a total of 25 female engineering students who major in Mechanical Engineering have been recruited as the interviewees in this study. By the time of this paper, we have conducted sixteen interviews and finished seven analyses of the transcripts, and five students concerned were from two classes of School A, two students from School B. This work-in-progress reported preliminary results from the seven analyses.

Data Collection Procedure

Methodologically, a phenomenographic approach was adopted to examine the variety of functional roles performed by female engineering students. It enables researchers to identify “the key aspects of the variation of the experience of a phenomenon rather than the richness of individual experiences” ^[36]. To ensure triangulation of the research method, qualitative data were collected through classroom observation and semi-structured interviews. Classroom observation was conducted in three different sessions of the course *Introduction to Engineering* in both School A and School B. In observing the class, particular attention was paid to female students' performance in group and their interactions with other members. Data from semi-structured interviews were used to analyze female students' group roles further.

As the theoretical framework of this study, Benne and Sheats' functional roles model served as a guidance for the design of the interview protocol. Specifically, students' functional roles were framed into the dimensions of task roles, social roles or individual roles respectively. Under the guidance of the functional role model, we designed an initial interview protocol, and then tested and revised it through four rounds of pilot interviews. Part of the final interview protocol is shown below (Table 4).

Table 4. Example Questions from the Final Interview Protocol

Descriptive Questions
<ol style="list-style-type: none"> 1. Can you describe the processes of completing your project in the course of Introduction of Engineering briefly? 2. What group roles did you play during project working processes?
Questions in the Dimension of Task Roles
<ol style="list-style-type: none"> 1. How did your team set up the goals of the project? 2. How did you accomplish your team goals and complete the project? 3. How do you evaluate your team's performance in completing the tasks of the project?
Questions in the Dimension of Social Roles
<ol style="list-style-type: none"> 1. How would you describe the processes of communications and discussions in your group? 2. What challenges in communication have you encountered during this project? 3. How would you describe the interaction and communication atmosphere in your group?
Questions in the Dimension of Individual Roles
<ol style="list-style-type: none"> 1. Did you have some expectation about yourself in the beginning of the project? Could you specify? 2. Did you find some characteristics of yourself during teamwork processes? Could you specify?

Data Analysis

To increase the validity of qualitative data analyses, we used both the observation data and interview data in our data analyses for triangulation ^[37]. In the process of data analysis, the records of classroom observation were used for primary understanding of female students' performance in team work. The information provided by one-to-one interviews were used to investigate female students' group roles further. All the seven interviews involved in this study were transcribed and reviewed carefully. For the sake of privacy protection, pseudonyms are used in the transcripts for all interviewees.

With regard to the coding process, a structured codebook was built upon the analyses of the seven transcripts, which constitutes a relatively stable frame for coding ^[38]. In developing the structured codebook, three categories (task roles, social roles and individual roles) were defined as priori codes in the first step. Based upon the priori first-level codes, open-coding was used to identify students' specific roles in these three categories. With the aim of understanding female students' various group roles, we coded female students' behaviors, thoughts and self-reported group roles within each category. After labeling the segments of information with codes, we analyzed, collapsed and classified codes into the three dimensions of roles.

To enhance the credibility of data analysis, an experienced researcher was invited to participate in the coding process. An auditing procedure was also conducted during the process of data analysis, which included the discussion of transcript interpretation, group roles categories and coding results. Codes were modified and refined for three times during and after the auditing process. Subsequently, a codebook was built, and will be used in the next steps of data analysis. Preliminary findings of female students' group roles are described below.

Results

In this section, we analyzed female students' group roles in the dimension of task roles, social roles and individual roles. Based on classroom observation and semi-structured interviews, we found that female students in project groups had taken on various task and social roles. Some of our preliminary findings in each dimension are presented as follows.

Task roles

Assistant

According to the existing data, being an assistant is found the most common role played by female engineering students in teamwork. Female students who take the role of an assistant tend to follow leaders' task assignment, and they are often assigned with, to some extent, peripheral work, such as purchasing materials, writing reports, crafting the presentation slides and so on. In contrast, limited opportunities are provided for female students in the process of design and production. Two segments concerning the role of an assistant is shown as follows:

*"...To tell the truth, my group tasks were **quite non-technical stuff**, like **buying materials, organizing documents and making PowerPoints**...Maybe it is because those boys in my group considered that I'm a girl. They always **arranged me to do some easier work**. Nevertheless, **I did hope I could try the production process**."*

——Mary

*"When there is only one girl in the group, it's common for the girl to do things such as **writing the report instead of the hard, manufacturing type, things**. In addition, boys are more interested in these things; they had a lot of ideas. And, they have the technique, or enjoy to dig into it. Therefore, my main role was to **assist them** so that they can concentrate on the task."*

——Anna

As illustrated by the quotes above, Mary's and Anna's tasks had few things to do with the core technical procedure, thus their function in a group is to assist other members by doing some non-technical work, such as "buying materials", "organizing documents", "making Power Points" and "writing reports", as mentioned above. They expressed their desires to be more involved in the hands-on process, from which they

can acquire more practical experience and hands-on skills.

Opinion Giver

Opinion-giver is one of the task roles that female students have played in the group project. Students who take this role contribute their ideas or opinions to the group, such as proposing alternatives to a product or different assessment plans based on their own expertise and experiences. For example:

*“When we were deciding on the choice of materials in making the intelligent eraser, whether it should be a wet wipe or a dry wipe, I **proposed** to use the materials in sponge mops to prevent dust of chalks, because I used to use the sponge mop to clean the blackboard when I was in high school. Then, we had a try and decided on using that material to make our product.”*

——Lily

*“I would **search online for useful information** first about force transducers in the market. For example, I’d like to know what is this products made of, how big it is, how much it costs and so on. ... We planned to make the force transducer by ourselves, and we needed to be familiar with the properties of those products. I got a rough understanding about those things through the search process, then I **would tell my partners** what materials we could use.”*

——Alice

As can be seen from Lily’s description, she proposed her ideas, shared her experience in high school, and put forward a new plan for her group in a decision-making process, thus played the role of an opinion giver. In Alice’s case, as an opinion giver, she searched the internet for useful information and provided those information and her opinions for her team members in the working process.

Coordinator

The following case shows that female students also play the role of a coordinator in a group, which means they help optimize their product by gathering ideas and suggestions from the group members. However, when taking this role, female students sometimes leave the part of decision-making to male students.

*“I usually **ask opinions from all the others**, so that everyone can express their own opinions, and their ideas might inspire anotherBut I am not the team leader, therefore I **definitely won’t try to control too much**. You see, if the team leader is present, I don’t think it is good to be involved too much, to control too much. So, I **will not try to involve myself a lot**.”*

——Susan

In this case, Susan self-reported that she often asked other members’ opinions and ideas for a better product. But she also avoided controlling too much when she was not a team leader. Moreover, it has also been found that female students taking the role of a

coordinator would pull ideas and suggestions together for discussion and organize activities for group building.

Initiator-manager

Only one of the seven participants took on the role of an initiator-manager: she came up with the project theme and led the whole project team, which consisted of three males and one female, including her. Just as what she said in the interview:

*“It’s my proposal to design an intelligent control device of intravenous drip bags, so those boys said, because it was **my idea**, I should be the leader...I mainly **played the role of a supervisor**. We had a task plan specifying the responsibilities of each member during each time frame. I **organized weekly meeting** so everyone can report their progress and the problems they encountered...I think this **leader position helped me integrate with those boys**. We had a lot of communications; they would listen to my idea. In addition, if you are very engaged, it can form a very positive atmosphere. ”*

——Jane

In this case, the female student came up with a plan, organized the group as the tasks unfolded, and assigned everyone different tasks in group working. She also held weekly meetings to check each member’s progress and discuss the problems they met in the process. As an initiator-manager, this female showed active performance and management in project working process, and became a core member of her group.

Social roles

Harmonizer

In the dimension of social roles, most female students reported that they played the role of a harmonizer, in which they tried to reconcile the disagreement among other members, relieve tensions in conflict situations and promote a harmonious atmosphere in the group work. According to the interviews, the work of harmonizing is mainly done by reasoning, adding humor, changing the topic, or having a personal talk with individual members. For example:

*“One boy in my group was a leader of the debate team in our school, and he was eloquent and a little aggressive. But the other boy who had different opinions with him was an introvert. He had his own ideas but he didn’t try to argue. If he was angry, he would just sit alone and keep silent. Thus, I **talked to them separately**, just to **improve their relationship**. In the end, they are ok with each other after the project.”*

——Susan

*“When we had some big argument, I would just say, let’s discuss something else, or I would **joke a bit to ease the situation**. Usually, if we have different opinions, we would try to let both sides express their ideas and arguments, then have a vote...Sometimes I would **propose to go out** for a dinner or do something fun together to **build the team spirit**. ”*

——Jane

In Susan's case, she played the role of a harmonizer through personal talk with each member involved in the conflict, and contributed to the group by resolving the conflicts than hindered the work progress. By the same token, Jane chose to tell jokes to alleviate the conflicts. As a harmonizer in a group, she also organized team activities to build the team spirit. Overall, these cases support the view that female students appeared to have better communication skills than male students, which proves the importance of gender diversity in project groups.

Follower

Female students who played the role of a follower reported that they did not have any good ideas, thus often accepted the ideas of others. When female students felt that their male peers did not hear their voice or when the group was having conflicts, they chose not to express their opinions and keep silent during group discussions and the decision-making process. As a result, they only passively accepted their work assignment and followed the leadership of the group, ensuring that they kept up with the flow as the project proceeded. Two examples of this are presented below.

*"Honestly, I didn't have many ideas, so usually **I did whatever the leader told me**, which usually included buying materials, improving the product's appearance, et cetera. ...Sometimes I had my own opinion, but when we were having a conflict, I would **choose not to express my ideas** for fear that the situation would become worse."*

——Mary

*"Two boys in my group had very strong personalities and sometimes were a little stubborn, so I **usually followed them**, so I had few conflicts with them."*

——Anna

The two examples above demonstrated that female students preferred to be a follower as a way to avoid conflicts. They tend to follow leaders' arrangement and keep silent in group discussion, especially when working with people with strong personalities.

Gatekeeper

Apart from the two social roles discussed above, several female students also self-reported their strength in having effective communications. Thanks to their good communication skills, they usually play the role of a gate keeper, that is, they summarize all team members' ideas or opinions and present them in a clear manner to group outsiders like teachers, teaching assistants and specialists.

*"I'm good at expressing ideas, so **most presentations were done by me**. They provided all information I needed for me, and I was responsible for the presentation, the exhibition."*

——Lily

As what Lily said, she usually acted as a gatekeeper in her group due to her good

communication skills and presentation skills. Based on the resources provided by other team members, she, as a representative, presented the results of the whole project team to teachers, experts and so on.

Individual roles

Outsider

Among the seven students we interviewed, three female students self-reported the feeling of being an outsider in their group, especially at the beginning of a project. Outsiders experienced disconnections with the group activities or performed non-essential tasks. They felt being isolated and unable to integrate into the group:

“I feel sad at the beginning because those boys made the product in their male dormitory, where I couldn’t get in! So I had to stay in my dormitory with nothing to do when those boys did teamwork in their place. It really made me upset, and felt like I was not needed in the group. Other girls in my dormitory encountered similar situations like this and they had the same feelings like I did.”

——Mary

“Sometimes I didn’t know how to get along with the boys because I was the only girl in my group, which made me feel nervous. Boys might think us girls were not fitful for hard labor, so they made the product by themselves...To some degree, I agreed with their opinions that boys are more suitable for some hard work such as drilling and sawing, so I wouldn’t volunteer myself anyway.”

——Anna

“As for the production process... I am a little ashamed. The other four students in my group are competent, but I felt that I had little talent [related to this work], and I had no previous project experiences. So I only watched them working on the project on the side and did not take part in this process. I just learned from the working process by observing.”

——Bella

In the first case, Mary failed to take part in the working process because the workplace was inaccessible to her, which made her quite sad. In the second case, Anna became an outsider because she was not comfortable to join a male-dominated group. One possible reason for her role of an outsider was her perception that the male students believed that female students were in weak position and lacking in engineering skills. In the third case, Bella did not participate in working process because she felt less competent than her peers in hands-on skills and had no previous project experiences. She only stood beside and observed how her partners worked on the project as an outsider.

Discussion

Our preliminary findings demonstrated a range of functional roles performed by female engineering students in the dimensions of task, social and individual roles in the context of collaborative project-based learning. The findings fill the gap of the existing research on collaborative project-based learning from the perspective of female engineering students' group roles. Because of the use of a phenomenographic approach, we were able to identify various functional roles performed by female students in group project. So far, in task roles dimension, we have found the roles of an assistant, an opinion giver, a coordinator and an initiator-manager; in the social roles dimension, we have found the roles of a harmonizer, a follower and a gatekeeper; in the individual roles dimension, we have found the role of an outsider. In the meanwhile, considering the particularity of collaborative project-based learning, we keep an open mind to new roles which may not be included in Benne and Sheats' functional roles model.

In addition, based upon the analyses of the roles that female students have assumed, we observed marginalization faced by some female students in this context, echoing the results in previous research ^{[7][20][39]}. According to the seven interviews, the reason for female students being marginalized might be the external circumstances or differences in individual strengths and capabilities. As indicated previously, some female students reported difficulties in integrating into the group and experiences of being assigned with non-technical or non-essential tasks, which left them a feeling of being left out. Prior research pointed out that group size, ratio of gender, and group dynamics were related to female students' performance and engagement in group interactions ^{[5][15]}. Furthermore, low female participants' representation and male dominance in a group were possible causes for female students' marginalization ^[23]. Prior research also showed that students' contributions, personalities, prior learning experiences and other factors were closely associated with female students' performance in a group project context ^{[7][21][22]}. An analysis of the possible causes of marginalization can help us develop strategies to improve female students' learning experiences in a group setting.

To solve the issues of marginalization, several suggestions are proposed here both for students and for teachers. First, similar to prior research findings, we believe that, in order to fit into a group and enhance group cohesiveness, female students should be more initiative to express their real thoughts and show their talents more actively ^[12]. Secondly, teachers should take actions to improve female students' learning experience. For example, teachers can set up specific standards to ensure effective task divisions, such as reporting task divisions and work stages regularly, or monitoring group working processes ^[40]. In the aspect of increasing female students' engagement in project-based learning, strategies taken by teachers can include interventions of group gender composition, process supervision of group members' engagement and gender equity education ^{[41][25]}. In addition, more skill trainings should be added into curriculum design of project-based learning, so as to help students develop communication skills, teamwork skills, leadership skills and other skills that are necessary for 21st century engineers ^[10].

To summarize, a spectrum of different functional roles can help us to have a deep understanding of female students' learning experience and their perceptions of the

learning experience in a group work setting. The findings of this study suggest different learning strategies in engineering courses for female engineering students. Furthermore, the results reported here could give suggestions for professors and faculty to improve the design of engineering curriculum, especially the incorporation of effective learning activities for female students. Last but not least, this study includes engineering courses from several contexts, including a joint institution collaborated between Chinese and U.S. universities. Further analyses can have practical implications for learning contexts with an international element.

Conclusion

This work-in-progress examined female engineering students' functional roles in a group project context to understand their learning experience in a male-dominant engineering course. The exploration of female students' functional roles promises an overall understanding about the effectiveness of collaborative project-based learning for female students. Future studies will continue to explore the diversity in female students' functional roles, their performance and associated impact factors. Our findings can provide direct implications for female students' learning strategies in engineering courses. Moreover, such findings can also render insights for engineering professors in their classroom management. Finally, our exploration of female students' functional roles can be used to inform the design of engineering curriculum and the incorporation of effective learning activities for female students.

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