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Female engineering students' learning experiences in an industrial senior high school: a preliminary study

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ABSTRACT: The purpose of the study was to analyse female engineering students' learning experiences in an industrial senior high school. Two main focus areas in the study were engineering learning climate awareness and engineering learning process. Qualitative interviews were implemented in a public industrial senior high school in southern Taiwan. Sixteen female engineering students participated in the study. A semi-structured interview guide was used to facilitate 40-minute student interviews. After qualitative data analysis, the study obtained 300 pages of transcript and 12 qualitative research themes could be identified. Overall, the climate threat in male-dominated learning environments did not limit female engineering students' engineering learning severely. However, due to the characteristics of the research participants, several unique themes about learning behaviours, not related to any past studies, were identified in this study.

Keywords: Women's studies, female engineering students in industrial senior high schools, engineering learning, engineering minorities, women in engineering, qualitative studies

INTRODUCTION

Background Information

In Taiwan, women in engineering come from two major sources: engineering colleges in universities and engineering departments in industrial senior high schools. The former (academic-track) recruits students from general senior high schools, the latter (career-track) admits students from high schools. The significant difference between two education institutions is the students' skill requirements. While female engineering students in industrial senior high schools receive several technical training programmes during three years of schooling, female engineering students in universities focus on academic knowledge based on engineering sciences during four years of classroom instruction.

In order to be successful in entering workplaces after graduation, female engineering students in industrial senior high schools need to have obtained at least two technical certifications. Even though the industrial senior high school is career-oriented, female engineering students also can apply to technological universities after obtaining a diploma.

Engineering departments in industrial senior high schools can be viewed as a microcosm of engineering colleges in universities. Engineering courses offered in industrial senior high schools are abridged versions of professional courses offered in engineering colleges in universities. For example, in the departments of electrical engineering in industrial senior high schools, electronics, engineering mathematics and circuitry are required courses for female engineering students. However, the instructional content in those courses is simpler than that offered in engineering colleges in universities.

Problem Statement

According to the Taiwanese Ministry of Education's statistical report, the number of female engineering students enrolling in industrial senior high schools is extremely low [1]. Overall, in one specific school, the ratio of male to female engineering students is about 10:1. However, in masculine-based departments, such as electrical engineering or mechanical engineering, the ratio can be up to 100:1 [2]. Since being in an engineering minority is a relatively recent research theme in engineering education [3], choosing female engineering students as a targeted research group can fit in well with this research trend.

Chou and Chang used a content analysis approach to analyse published articles from 2000 to 2009 in one refereed engineering education journal and reported that past studies related to women in engineering were few in number [4]. Chou further examined studies related to women in engineering in three refereed engineering education journals and found that previous research tended to use female engineering students in universities as research participants and no past studies focused on female engineering students in K-12 education systems [5]. This research examines female students in industrial senior high schools, that is, in K-12 learning institutions. An in-depth exploration of these groups could provide additional information about current studies dealing with female engineering students in universities.

In the existing literature regarding K-12 engineering education, most studies emphasised K-12 students' understandings of engineering knowledge and ignored the existence of female engineering students in K-12 schools. For example, Little and Barra surveyed 74 students from fifth to ninth grades about their attitudes toward engineering [6]. Karatas, Micklos and Bodner interviewed 20 sixth graders about the concept of an engineer [7]. Due to limited discussions in the literature, the current study could serve as a pioneer-based study to concentrate on female engineering students in industrial senior high schools.

Building on the above information, this study aimed to adopt a qualitative methodology to explore female engineering students' learning experiences in an industrial senior high school. The learning experiences focused on two areas: engineering learning climate awareness and engineering learning processes. Specifically, the research questions were twofold:

1. How did female engineering students perceive male-dominated learning environments (engineering learning climate awareness)?
2. How did female engineering students self-manage their learning processes and tasks (engineering learning processes)?

METHODOLOGY

Research Design

This study adopted a qualitative methodology to explore female engineering students' learning experiences in an industrial senior high school since a qualitative approach allowed the researcher to identify all preliminary phenomena to be uncovered in the research questions [8].

The main data collection method was an intensive interview design. Before the implementation of the study, three field experts, including one schoolteacher in an industrial senior high school, one professor of engineering and one professor of education were invited to discuss the contents in an interview guide. Following two rounds of discussion, the final version of the semi-structured interview guide used in the study appears in Table 1.

Table 1: A semi-structured interview guide.

Construct	Main ideas	*Supported literature
1. Engineering learning climate awareness	1. Learning atmosphere in laboratories and classrooms 2. Teacher and peers' attitudes 3. Learning support in departments	Gallaher and Pearson [9], Baker, Tancred, and Whitesides [10], Schafer [11], Stonyer [12]
2. Engineering learning process	1. Learning strategies in engineering subjects 2. Collaborative learning experiences 3. Self-directed learning status 4. Self-efficacy evaluation	Du [13], Du and Kolmos [14], Schreuders, Mannon, and Rutherford [15], Shull and Weiner [16]

*Since no past related studies were identified in the literature, this study borrowed the findings yielded in the research in which the research participants were female engineering students in universities.

Each interview was completed within 40 minutes. A professional digital audio recorder was used to record all interviews. A study room in the industrial senior high school was chosen as the interview location. Each student participant was required to sign a consent form before the beginning of the interview. Once the interview was finished, students received a gift bag for research *compensation*.

Research Participant

This study adopted convenience sampling to collect data. A public industrial senior high school in southern Taiwan was selected as the targeted research source. The researcher recruited participants through research advertisements posted on campus. After a two-week promotion, 16 twelfth graders were recruited. These female engineering students came from several engineering departments. Table 2 lists profiles of the research participants.

Table 2: Profiles of research participants.

Department	Number
Architecture engineering	8
Electrical engineering	2
Civil engineering	2
Mechanical engineering	4
Total	16

Data Trustworthiness

This study employed three strategies to ensure the reliability of the qualitative data:

1. Transcript checking: after the recorded contents were transcribed completely, a research assistant was hired to double-check the contents between recorded contents and transcripts in an effort to ensure data consistency.
2. Member checking: transcripts were sent to all research participants to ensure content reliability.
3. Category checking: once initial themes in qualitative data were identified, six research participants were invited to discuss the contents and share their opinions in a focus group meeting. Several contents in themes were modified during this time.

Data Analysis

Moustakas's four-stage phenomenological analysis was used to analyse all transcripts: preliminary grouping, clustering of invariant meaning units, searching for themes and composite textural-structural descriptions [17]. During data analysis process, NVivo 8.0 qualitative analysis software was also used to search and compare the digital transcripts.

FINDINGS AND DISCUSSION

After qualitative data analysis, the study produced a 300-page transcript and 12 qualitative research themes were identified. The text-description themes with simple quotations from research participants were presented as follows:

Theme 1: New Learning Challenge at Campus

Before enrolling at engineering departments, several female engineering students had prior knowledge of the male-dominated learning environments in industrial senior high schools. However, they still felt that studying in new learning environments was a challenge for them. Being in a learning minority, female participants considered that male peers often looked attentively at their learning behaviours. For example, S3 stated, *We look like animals in the zoo. My male peers look like zoo victors. They watch out our behaviour all the time*. S1 said, *It is uncomfortable for me. They want to know what happened to us. We were like goldfish in a fishbowl.*

Theme 2: Buddy Relationship with Male Peers

In the male-dominated learning environments, most of the female engineering students perceived that after shifting from a tenth grade (freshman year) to an eleventh grade (junior year), their male counterparts treated them as a male buddy and might discuss some gender discrimination issues in front of them. However, the female engineering students would hide uncomfortable feelings in their minds. For instance, S3 stated, *I am wondering why they often talk about that. They seemed to forget about my gender*. S7 said, *Two years after studying with my peers, I feel that I gradually adapted to their school behaviours even though they take gender issues as laughing matters*.

Theme 3: Spiritual Support from Female Classmates

Due to the nature of learning minorities, most of the female engineering students felt that female classmates provided them with spiritual support. The same gender allows them to form a small group, which can confidentially talk about private matters and share ideas about engineering learning. For example, S9 stated, *There are two female students in my class. We are close to each other. We will share things that happen at school*. S13 said, *My female classmates and I often have a heart-to-heart chat. It is weird to talk with those guys in my classes*.

Theme 4: Positive Support from Male Instructors

Most of the female engineering students enjoyed the male instructors' instructional strategies. In the students' minds, male instructors were father-figures who always cared about what they needed. After class teaching, male instructors might ask them if the course materials provided were appropriate for them. For example, S10 stated, *Maybe we are female. They always care about my learning status. They want to know which sections of the materials are difficult for*

me. S12 said, *Male instructors are very nice. They treat us like their daughters. They are willing to make extra efforts to take our suggestions about class teaching*.

Theme 5: Poor Facility Support by Engineering Departments

Almost all the female engineering students expressed their discontent with the engineering departments. They considered that school administrators ignored learning minorities' needs for friendly facilities. All physical facilities were designed for male students. For example, S1 stated, *Can you believe that our three-floor department building only has one bathroom for women? It is so crazy*. S6 said, *I think our school only focuses on male students. Establishing something for women maybe cost more money*.

Theme 6: Learning Difficulties in Engineering Subjects

Engineering subject learning directly related to mathematic capability. Due to lack of robust training on mathematical computing, several female engineering students found it difficult to learn engineering subjects. For example, S8 stated, *Architecture major focuses on mechanics. I am not good at mathematics. I have a hard time doing mechanics homework*. S9 said, [There is a] *lot of mathematical computing in my textbooks. I think my mathematical skills are poor so that my learning performance is not very good*.

Theme 7: Enjoying Hands-on Training Courses

Compared with theory-based curricula, most of female engineering students enjoyed learning in practical courses. They considered that hands-on training courses motivated their learning desire and allowed them to apply theory into practice. For instance, S13 said, *I love to manipulate mechanical machines. Such hands-on experiences satisfy my learning curiosity*. S12 stated, *I can learn several practical skills in these courses. Such experiences will also provide me more job opportunities*.

Theme 8: Seeking Help from Male Peers

When facing learning difficulties, female engineering students used to seek help from their male peers rather than course instructors, who are often regarded as authoritarian figures in Taiwanese culture. Moreover, since the top students were male peers, female classmates were not prime candidates for learning consulting. For example, S12 stated, *My first reaction is to ask my male peers, because the top five students in my class are male*. S6 said, *My male classmates are my first consulting choices. But, I will ask questions from nice guys. Some top male peers are cool in manner*.

Theme 9: Collaborative Learning for Professional Development

Collaborative learning allows students to pick their team members to form a student group. Several female engineering students tended to work with well-performed male peers because male team members could support their professional development. For example, S9 stated, *Working with male peers can alleviate my learning anxiety. They often support my learning as I am stuck in a learning task*. S11 said, *My group only has one male member. He often shares creative ideas I never thought about before. I think such collaborative learning can enhance my understanding about engineering subjects*.

Theme 10: Male Learners Excelling at Engineering

Almost all female engineering students perceived that male peers were quick learners of engineering learning. In their minds, male students had a gift for receiving engineering knowledge. For example, S1 said, *I am still wondering why my male classmates grasp the engineering knowledge so quickly*. S16 stated, *Taking practice lessons for example, my male peers complete learning assignments so fast. I have a hard time catching the process*. However, such learning behaviours often create a learning pressure for few female engineering students. For instance, S10 said, *Their quick responses to engineering assignments lead to me questioning my self-ability in engineering*.

Theme 11: Cram School *Learning Experiences*

Since several female engineering students are not good at theory-based engineering subjects, they would spend extra time going to *cram schools* after school in order to strengthen their engineering knowledge. They expected that learning materials provided by cram schools could cover their learning weakness. For example, S9 stated, *In school, I cannot totally absorb the knowledge taught in class. The learning materials in cram schools allow me to easily understand key points*. S14 said, *Schoolteachers cannot take care of all students in a big learning environment. Going to cram school is my decision. I think the cram school boost my self-efficacy in engineering learning*.

Theme 12: More Efforts on Technical Certification

Since industrial senior high schools are career-oriented, most of female engineering students are extremely concerned about whether they could obtain technical certification before graduation. In such a learning atmosphere, female

engineering students paid attention to course instruction in hands-on training classes. Moreover, certification proves that they have achieved technical skills to a professional level. For example, S13 stated, *I spend much time training my skills. Getting technical certification allows you to have more job opportunities*. S15 said, *Hard work will pay off. More practice may be helpful for the certification exams. If you get more certificates, job finding or university application are more likely to be successful*.

Compared with the existing literature about female engineering students in universities [9][10], the findings yielded in this study showed that the *climate threat* did not severely limit female engineering students' engineering learning in the industrial senior high schools. Even though they complained about poor facilities in engineering departments and gender-related scoffing from their male peers, female engineering students still received positive support from male teachers and spiritual support from female classmates. Such scoffing may suppress female engineering students' discontent.

The findings also indicated that female engineering students enjoyed working in a team-based learning environment where male counterparts supported their engineering learning. This result is consistent with the report in Du's study [13]. However, unlike the findings in past research [11][12], two themes in qualitative data showed that male peers would be willing to help female engineering students solve learning difficulties for professional development. Due to the characteristics of research participants, several identified themes, not related to any past studies, were unique in this study.

CONCLUSION

The purpose of the study was to analyse female students' engineering learning experiences in the industrial senior high school. The main focus areas in the study were engineering learning climate awareness and engineering learning process. Twelve themes were identified in the qualitative data. Overall, the study yielded abundant data about female students' engineering learning experiences. However, since this study serves as a pioneer-based research, a few more related studies could be used to support the findings.

Due to the nature of qualitative research, the findings yielded in the study cannot be applied to other engineering learning environments, particularly for higher education institutions. The unique learning phenomena relating to female engineering students in the industrial senior high school still need further verification by future related studies, which can select other student participants in other districts.

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BIOGRAPHY

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