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Masako Hosaka^a

^a Department of Educational Leadership & Policy Analysis, University of Missouri, Columbia, USA

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Women's experiences in the engineering laboratory in Japan

Masako Hosaka*

Department of Educational Leadership & Policy Analysis, University of Missouri, Columbia, USA

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This qualitative study aims to examine Japanese women undergraduate engineering students' experiences of interacting with departmental peers of the same year in the laboratory setting by using interview data of 32 final-year students at two modestly selective national universities in Japan. Expectation state theory that explains unequal relationship between men and women is used as a framework. Findings suggest that women generally had a discouraging experience while working with their male peers. Specifically, women participated less and lost confidence by comparing with the men who appeared to be confident and competent.

Keywords: women in engineering; higher education; hands-on-experiences

1. Introduction

The under-representation of women in engineering has been a perennial problem in many countries. In Japan, where the proportion of engineering graduates who are women has remained at around 10% since 2000 (National Institute of Science and Technology Policy, MEXT 2012), the government has been making efforts to stimulate interest in the field along with other science-related fields of study among the younger generation ([Bureau of Council for Science and Technology Policy, Cabinet Office, Government of Japan 2011](#)). However, there is no guarantee that women who enter undergraduate programmes will pursue a career in engineering. In fact, national data show that women leave the field of engineering at a higher rate than men when they graduate from college. Compared to male graduates, a smaller proportion of female graduates obtains an engineering-related job and goes on to a master's degree programme, which would increase their likelihood of obtaining a professional job ([MEXT 2010](#)). In addition to making such recruitment efforts, engineering schools should question what causes women in engineering to make a different postgraduate decision than men.

Studies worldwide have reported that women face extra challenges in developing a professional identity in engineering, a male-dominated field of study ([Dryburgh 1999](#); [Du 2006](#); [Powell, Bagilhole, and Dainty 2009](#); [Tonso 1996](#)). It is important to demonstrate what women experience in college and envision what it would be like for them to work in this field. The present social psychological study aims to contribute to our knowledge of women's experiences in engineering by focusing on their interactions with their peers in a laboratory setting in Japan. Laboratory work provides students with an opportunity to engage in field-specific tasks and receive feedback on their performance, as well as to develop familiarity with working in a professional setting through interactions with colleagues.

*Email: happyamasako@yahoo.com

2. College experiences of women engineering students

Studies of engineering students' experiences in laboratory or other group work which entails peer interaction have found that women have negative experiences with their male peers. In particular, being a lone woman in a group hurts a woman's opportunities for learning (Rosser 1998; Tonso 1996). Women in engineering also find that they have to negotiate their female identity, and that their contributions are not valued much (Du 2006; Felder et al. 1995; Seymour and Hewitt 1997; Tonso 1996; Vogt, Hocevar, and Hagedorn 2007). This negative experience has to do with the difficulty of achieving cooperation among individuals of different genders, ages, experience levels and motivational levels (Colbeck, Campbell, and Bjorklund 2000; Natishan, Schmidt, and Mead 2000) and also with students being required to work together without faculty monitoring or guidance (Amelink and Creamer 2010; Colbeck, Campbell, and Bjorklund 2000). More study is necessary in order to fully understand women's experiences in peer interactions, which seem to play a role in women's educational aspirations or attainment in the field of engineering.

Only a limited number of studies have been conducted in Japan concerning women's experiences in engineering, either in the workplace or at a university. Yet, these studies provide a glimpse of women's experiences in engineering schools that are gendered (Hosaka 2010; Kawano 1997; Koinuma 2009; Matsuura and Namie 2002). For example, a survey of alumnae and current female students at an engineering college revealed that special treatment was one of the important sources of women's dissatisfaction and concerns (Koinuma 2009). In another study, women graduate students of two engineering schools reported that their integration into the institution mainly occurred in the final year of their undergraduate study when they entered a research unit (Hosaka 2010). It should be pointed out that women's accounts of their experiences in the first three years of their undergraduate studies are limited.

3. This study

The purpose of this study is, first, to understand how women engineering students in Japan experience laboratory work in their first three years of study, and then to interpret their experiences in making their postgraduate decisions. Laboratory work is defined here as any hands-on experience in which students engage in task-oriented activities with others in an academic setting, including traditional laboratory work and problem-based learning. The phrase 'any *jikken* or *jisshu* experience' in Japanese was used to obtain these experiences in the interview. Since the focus of this study is the interactions, not the work itself, students from multiple specialties were included.

This study is part of a large study, which examines women engineering students' various academic experiences with multiple constituents within a department (e.g. faculty, peers and graduate students) in relation to their postgraduate decisions (Hosaka 2013). Pursuing this study in Japan, where employers make the hiring decisions of each year at the beginning of the previous year, made it possible to interview fourth-year students who had just completed the coursework and at the same time determined their postgraduate plans. Students' postgraduate plans are considered to be indicative of the relative importance of their engineering identity. The following research questions guided this particular study:

- (1) What do women engineering students perceive about their experiences in the laboratory at Japanese engineering schools?
- (2) Are women engineering students' laboratory experiences gendered? If so, how?
- (3) How do experiences differ between women who plan to pursue a master's degree (Group 2) and those who plan to obtain a full-time job immediately after college (Group 1)?

4. Theoretical framework

This study employs expectation states theory (EST) as the theoretical framework. EST posits that in goal-oriented settings, individuals use cultural beliefs about the status implications of their distinguishing characteristics, such as gender, race and age, to organise their interactions (Berger et al. 1977; Carli 1991; Ridgeway 1993; Wagner and Berger 1997). The theory claims that the status characteristic becomes salient in a setting in which it either differentiates the actors or is culturally linked to the task at hand.

In a society which considers men to be more competent than women, within a mixed-gender group which is performing a task that is culturally linked to the men's work, men are more likely to participate in the task-related activities, take a leadership role and be evaluated more leniently than women. EST was used by Ridgeway (2009) and Ridgeway and Smith-Lovin (1999) to explain gender inequality among formal peers in conjunction with West and Zimmerman's (1987) 'doing gender' perspective. While the latter perspective that is based on Goffman's (1959) concept of impression management considers that gender is an outcome of performance in interactions, EST, a more structurally oriented social-psychological theory, asserts that gender itself also influences interactions between individuals in different social positions. The use of EST that explains individuals' participation in a task and evaluation of task performance in a task-oriented setting will provide us with the means to link women's experiences with their gender and postgraduate decisions that will lead them to different social positions.

5. Methods

Considering the dearth of studies on women in engineering in Japan, the author decided to use the qualitative method, wherein she primarily collected data through in-depth, semi-structured individual interviews and analysed the data inductively.

Thirty-two final-year women engineering students were recruited from two moderately selective national universities in Japan, Western University and Central University (pseudonyms), which shared many characteristics, including institutional size, women's representation and the proportion of graduates who immediately go on to a master's degree programme. The interviews were held a few months after the start of the academic year, so as to ensure that the participants had already decided on their postgraduate plans. By that time, final-year students had completed all coursework and entered a research unit where they engaged in a capstone project. Major firms also had completed their recruitment of prospective college graduates, and graduate programmes had started the admission process.

All female students who volunteered, 17 from Western University and 15 from Central University, were interviewed, including 19 (10 from Western University and 9 from Central University) who planned to go on to a master's degree programme after college. It should be noted that some participants who planned to start working full-time after obtaining a bachelor's degree were going into other fields. In each 90-minute session, the author obtained an informed consent from each participant, interviewed her for 50–60 minutes and conducted a member check, which is a procedure to make the finding of the qualitative study credible (Lincoln and Guba 1985). Towards the end of the interview, the author asked participants whether they believed that their gender influenced their overall collegiate experiences and in what ways they perceived that it did. This question was asked towards the end because the author was concerned that bringing up the topic earlier might sensitise the participants to the issue of gender.

After analysing the data by using constant comparative methods (Glaser and Strauss 1967) to explore possible themes, the author identified the key themes. She further coded the data

systematically according to the identified themes that describe women's experience. Due to the qualitative nature of the study, the author does not claim that these women's experiences can be directly applied to women in other engineering schools in Japan or other countries. To this end, further qualitative and quantitative work must be conducted to confirm consistency of the findings in this study.

6. Findings

Participants often cited laboratory work as the place where they realised their aptitude (or lack of it) in the field. Participants generally appreciated the opportunity to apply their knowledge, with the exception of those who intended to work in a non-engineering field immediately after college. Regardless of the participants' intuitive affinity for the field, however, they experienced the laboratory environment as challenging to participate actively. As we will see in this section, the interactions with other students, which differed by the groups, seemed to influence students' development of an affinity with the field. Because a qualitative study is not suited for claiming differences in a quantifiable way, experiences that are characteristic to either group will be introduced to illustrate the differences.

6.1. *Being a token individual*

Women students, including those in a relatively gender-balanced programme, often found themselves to be the only woman in a group. Participants alluded to the idea that the instructors' benign consideration of placing women evenly in each group was the cause of this. Participants were unfamiliar with any of their own group members when the laboratory work started, especially in the early years of their programmes, because the social network of their department was generally limited to women. When asked about their laboratory experience, participants mentioned their token status first, as if this was the most important facet of laboratory work.

Participants acknowledged that the men in their programme inevitably perceived and treated the women in the group differently because they rarely mixed with the women. However, working as a lone woman made some participants feel isolated and disadvantaged. For example, Keiko (Group 1, Western University), who doubted her full membership in the group, complained about the superficial nature of the group cooperation: '[In our group] the men and I talked, but we only talked when we needed to talk.' When a team spontaneously decided to work on reports after class, men often excluded the women from the study group. Yoshie (Group 2, Western University), recognising the harmful impact the exclusion from out-of-class study meetings had on her learning, joined the group whenever she found other members studying in the library.

6.2. *Lack of participation*

The laboratory work provided the participants with opportunities to make small talk while waiting for an experiment to finish and acquaint themselves with their male peers. Since the number of hours students engaged in the laboratory work increased as the year progressed, the participants became more familiar with the male members of the group in their third year than in previous years.

The participants generally evaluated the social aspect of the laboratory work as beneficial. The laboratory, however, did not nurture the kinds of behaviours and interactions which promote learning for all students. The engineering students, feeling always busy due to a heavy workload, tried to complete the required work as efficiently as possible during the class. The participants

were discouraged by the work style of male students in which the students blatantly criticised each other's work and the competent students did most of the job. Except for a few participants who indicated their active role in the group work (e.g. telling other group members what to do), the women thus did not actively participate in the group work. They deferred to the male students, rarely asserting themselves in the group, especially when the group was dominated by a man who wanted to do everything by himself. Consequently, the women often missed an opportunity to engage in or even observe essential parts of the work. The lack of participation made some participants dislike working in a group.

Some Group 2 students actively tried to contribute to the group work in a supplemental capacity. Kaori (Western University), who was conscious of her gender, considered that she, as a woman who was an 'outsider' to the male group members, played 'a connecting role' by easing tense communication in the group. Another example is Sayo (Central University), who often found herself in a supporting role when working with an assertive male student:

I offered group members help: 'Let me wash this'. Sometimes, all I did was wash instruments for the experiments. I am the kind of person who feels responsible for whatever is left to do. If someone starts doing something, I will just let them do that [even when the task they have chosen is what I was going to do].

Participants understood the varieties of women's experiences across groups because women shared their experiences among themselves. Women with both passive and positive outlooks concluded that the individuals with whom they worked mattered to what women experienced.

6.3. *Evaluation of one's aptitude*

Through working in a group, women developed the impression that male students would be better engineers than themselves. This perceived sense of inferiority in the field, which is widely shared among the participants, seemed to be based on social interactions, not objective criteria.

One source of the participants' loss of confidence was the male students' confident attitudes. For example, Moe (Group 1, Western University) observed that some male students were smart because they confidently pointed out and corrected others' mistakes. Another source had to do with the perceived quality of the end products. After starting working in a group, Yayoi (Group 1, Central University) observed the male students' assignments and wondered whether she was performing well enough. In the first two years when the number of hours in the laboratory was limited, women rarely had chances to observe how men work. In their third year, participants had much more opportunities to work with men.

For some Group 1 students, their lack of confidence and self-doubt about their ability to succeed in their major appeared to be further undermined by their being revealed as incompetent students. In fact, these Group 1 students remembered a specific incident in which they made mistakes or obtained inaccurate results. Although this seemed to be partly due to their lack of understanding of the subject because these students often expressed confusion about what they were doing, the presence of other students who were pursuing a good grade through doing efficient group work also seemed to make women's experience more stressful.

Again, the participants perceived either pressure or support from their group members, indicating the importance of the presence of male students in their performance. While one participant was able to tenaciously repeat the task with her lab partner until they obtained a proper result, Jun (Group 1, Central University), one of the few participants who cited the laboratory work experience as a reason for not to pursue a career in engineering upon graduation, often failed at experiments and was embarrassed by the presence of others:

I felt embarrassed [for other members] because I often failed at the experiment. My co-worker would tell me, 'Don't worry', but I had come to develop a sense that I was not good at doing the experiments. I guess that is why I had grown to dislike doing the work.

Group 2 students also explicitly expressed their admiration of male students' confident attitude and performance. Compared with Group 1 students, these students who planned to pursue a master's degree considered themselves reasonably good performers and rarely worked without a clear understanding. However, they attributed their grades to hard work, while attributing the male students' good performance to talent.

7. Discussion

The findings of this study revealed that laboratory work failed to provide the women with an ideal learning setting in which they could actively participate in the task and develop a sound self-evaluation. The laboratory work exhibited various aspects of EST that increased the salience of the gender. The students engaged in masculine tasks in a highly skewed mixed-gender group without knowing each other. While the nature of the engineering task was given, the gender composition of the group and the knowledge of group members could have been altered. What is worse, performing a task well was important because students were graded according to their group outcomes. This study confirmed the importance of women's interactions with male students in the development of their confidence in pursuing a professional career and suggested further that the social nature of the development of confidence is inherently determined by the unequal relationships between men and women.

Unlike previous studies (e.g. Du 2006), the women participating in this study did not claim they needed to avoid being evaluated by others unfairly due to their gender, which was in conflict with engineering identity. The lack of evidence for identity negotiation, however, does not necessarily mean that women engineering students in Japan did not perceive the need to display their competence to others. The female participants in this study seemed to attempt avoiding the possibility that their competence would be unfairly judged, either by not assertively participating in the group work or else by not contributing to the work in a way that hindered the work of others. It is troubling to see that Japanese women in this study, regardless of their postgraduate plans, seemed to internalise their low self-evaluation largely on the basis of their interactions in the laboratory. The development of the participants' confidence seemed to be thwarted by the sudden exposure of the male culture in which women were constantly reminded of their minority status in the interactions.

Students' different experiences according to their postgraduate plans might help explain the importance of personal interactions and their strategic role in students' sense of fitness for their profession. The findings of this study indicate that on the one hand, some Group 1 students appeared to be traumatised because they projected an image of an unreliable performer to other members, which indicates the extent to which this experience lowered their status. On the other hand, Group 2 students' positive attitudes towards the work in a group, although in a limited capacity, might be the evidence that they were not only motivated but also aware of the importance of working well with male students to their professional success.

In addition to the differences in the students' experiences and attitudes towards personal interactions in relation to their postgraduate plans, women's experiences in the laboratory were different across time as far as their level of comfort in working with men. Although I lacked evidence which compares participants' laboratory experiences by program year, EST explains the temporal change. By acquiring academic and social skills and learning more about their colleagues over three years, the women might have felt more comfortable working in a group. The men might also have changed their perceptions of the women as they came to know a female member better. In other words, both male and female students came to have a more accurate performance expectation of each other through obtaining information about the task-relevant aspects of individuals

with whom they worked. The Group 2 students' plan to pursue a master's degree might also have boosted their status in personal interactions.

Additionally, sharing experiences among women might have facilitated the process of women becoming more informed about their status. Although the participants could not help each other in the same way as they could in a lecture-type class (e.g. studying together after class) because they were members of different groups in the laboratory, they supported each other by rationalising their own situation as women.

8. Implications

While examining the influence of one's grade is common in studies on students' persistence, qualitative studies of women's experiences in engineering have not accounted for students' grades or their sense of understanding. Despite the unavailability of objective data on students' understanding of a subject (e.g. student records), the findings of this study suggest that students' sense of understanding might play an important role in reducing the risk of exposing one's incompetence. Accounting for students' understanding of the subject will thus improve our comprehension of women's laboratory experience.

In future studies which specifically examine the experience of women engineering students, researchers should focus on a particular field of study that has a specific set of tasks. Collecting students' accounts and observational data concurrently with the coursework or longitudinally will enrich the data. Particularly, the observational data would reveal aspects of which the participants themselves are unaware.

Regarding the practical implications, the most basic problem is that groups typically include just one woman. Given this study's findings, which corroborate the literature regarding gender composition (Rosser 1998; Tonso 1996), at least two women should be included in a group.

In addition to the group composition, instructors should take more direct, intentional action to influence group dynamics through guidance, monitoring and feedback. Students first need guidance about laboratory work that involves working in a mixed-gender group and learning outside the classroom. Students should be encouraged to work cooperatively and increase their awareness of gender differences in working styles and modes of communication. Instructors should also monitor how students work on tasks and interact inside and outside the classroom. Although this is a speculative assertion, because the extent of instructors' involvement was not systematically investigated, the students seemed to be left alone during the laboratory work, as was observed in previous studies (Amelink and Creamer 2010; Colbeck, Campbell, and Bjorklund 2000). However, this is problematic, given that students tend to assume a certain role only once their position in the group is established (Colbeck, Campbell, and Bjorklund 2000). Last, students should receive proper feedback and evaluation from the expert in the field (i.e. the professor) to avoid excessive reliance on self-ratings, which people often do when they lack objective criteria.

Findings also indicated that working in a mixed-gender group was challenging to most women students, especially at first. Considering the long-term benefits of working in a group, it might be helpful for engineering students to start working in the laboratory or in group at an early point in their studies, which will confirm their understanding of coursework and help them integrate successfully with their peers.

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About the author

Masako Hosaka is currently a Ph.D. candidate for Higher and Continuing Education at the University of Missouri, Columbia. Her research interests are women in higher education and faculty socialisation.