International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

"I Wouldn't Ask Professors Questions!" Women Engineering Students' Learning Experiences in Japan

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ABSTRACT
This qualitative study examines the experiences that Japanese women have as engineering undergraduates while interacting with departmental faculty. It accomplishes this by using interview data from 32 final-year students at two universities in Japan. The theory of 'role as resource' (Baker & Faulkner, 1991; Callero, 1994) is used as the theoretical framework. Findings suggest that the women's feelings of alienation in engineering classes were due to instructors' poor teaching and aloofness, which influenced both their lack of engagement in learning (in and outside the classroom) and the difficulties they perceived in approaching instructors with academic questions. The women students used various strategies when they decided to approach departmental faculty, based on their level of understanding of the subject matter and the extent to which they felt comfortable initiating contact. Availability of peer assistance also determined whether students asked questions of instructors. Despite satisfactory encounters, participants typically did not develop ease with the departmental faculty. Only a few participants overcame initial difficulties, utilized the role of student as resource well, and acquired additional resources (i.e., a better understanding of the subject matter and a meaningful relationship with the faculty). From these findings, practical implications for improving women students' learning experiences in engineering, which is important for reducing their attrition from the field after college, are offered.

KEYWORDS
Japanese women; engineering education; student-faculty interactions

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INTRODUCTION

Underrepresentation of women in the sciences, technology, engineering, and mathematics (STEM) fields during and after college has been a perennial problem in many countries. In Japan, the proportion of female graduates has remained at roughly 10% in engineering, after an increase in the late 1990s (National Institute of Science and Technology Policy [NISTP], 2012; Ministry of Education, Culture, Sports, Science, and Technology [MEXT], 2010). Alarmed by the shortage of highly skilled workers and an enrollment decline in undergraduate STEM programs (Nomura Research Institute, 2010), the Japanese government has been making efforts to stimulate interest in STEM fields among the younger generations (Bureau of Council for Science and Technology Policy, Cabinet Office, Government of Japan [BCSTP, CO, GJ],2011).

Considering that college students in Japan rarely change their majors because of the inflexibility of the higher education system, the current effort to increase the number of entrants to undergraduate STEM programs seems to be effective. However, there is no guarantee that women who enter these programs will pursue careers in STEM fields. National data show that women leave these fields, especially engineering, at a slightly but steadily higher rate than men at the point of college graduation; a smaller proportion of female than male graduates obtain jobs within these fields and continue to master's degree programs, which would increase their likelihood of obtaining professional jobs (MEXT, 2010). Women's low persistence rates in engineering beyond college in Japan, where a strong Confucian doctrine is present, is somewhat understandable given that they exhibit lower educational and career attainment than do men (Amano, 1997; Brinton, 1988; Yamamoto & Brinton, 2010). Although roughly half of college entrants are women, men still outnumber women in graduate programs by a ratio of two to one (MEXT, 2010).

To understand the dynamics of the postgraduate decisions of women engineering students in Japan, it is important to understand what women experience and how they envision working in the field. In engineering, students learn about the field and the profession through college training that provides not only field-specific knowledge and skills but also information about the nature of work and the culture of the field. This study aims to contribute to our knowledge of female engineering students' collegiate experiences, which play a critical role in their educational and career decisions after graduation. It will do this by focusing on their academic interactions with faculty, who are important agents of professional socialization (Weidman, 1989).

COLLEGE EXPERIENCES OF WOMEN ENGINEERING STUDENTS

Because there are only a limited number of studies on women's college experiences in Japan, I will primarily use studies conducted in the United States and other Western countries with the caveat that they may not adequately reflect the Japanese context. They do, however, provide the most robust literature base. A significant number of studies have documented the positive impact of teaching practices (Colbeck, Cabrera, & Terenzini, 2001; Pascarella, Wolniak, Pierson, & Flowers, 2004) and informal student-faculty interactions (Hearn, 1987; Kuh & Hu, 2001; Sax, 2001; Sax, Bryant, & Harper, 2005; Tsui, 1995) on college students' educational aspirations and enrollment in graduate programs. Research has found that the frequency of student-faculty interactions was predicted by instructors' classroom behaviors (Cole, 2007; Cotton & Wilson, 2006; Wilson, Wood, & Gaff, 1974) along with students' grades (Cole, 2010; Kuh & Hu, 2001) and interactions with peers (Cole, 2007; Lundberg, 2003). Researchers have also reported that women seek more frequent and personal contacts with the faculty than men (Kuh, 1995; Nadler & Nadler, 2001; Sax et al., 2005). Despite rich research evidence, the exact manner in which different forms of student-faculty interactions occur and influence one another has remained unclear (Cotton & Wilson, 2006).

In STEM, where students of both genders and at all levels complain about poor teaching (Seymour & Hewitt, 1997), studies have shown the importance of faculty in women's persistence in STEM fields; the more support and encouragement women receive from the faculty, the more likely they are to aspire to continue working in the field (Amelink & Creamer, 2010) and actually persist after college (Rayman & Brett, 1995; Sax, 2001). However, women are less likely than men to report satisfactory classroom experiences (Colbeck et al, 2001; Heller, Beil, Dam, & Haerum, 2010) and less likely to report equitable treatment (Darisi, Davidson, Korabik & Desmarais, 2010; De Welde & Laursen, 2011; Vogt, Hocevar, & Hagedorn, 2007) or adequate feedback from faculty on their academic performance (Baker, Tancred, & Whitesides, 2002; Seymour & Hewitt, 1997).

Whereas the different experiences of men and women in engineering are often treated as issues of self-efficacy and learning styles, researchers have also argued that the central issue is the development of identity in engineering. Some have argued that women need to negotiate their gender identity within engineering's competitive, masculine culture in both educational (Dryburgh, 1999; Du, 2006; Powell, Bagilhole, & Dainty, 2009; Tonso, 2006) and work settings (Faulkner, 2009; Hatmaker, 2012; McIIwee & Robinson, 1992). Others have identified multiple dimensions (e.g., academic and social) of engineering identity, which may or may not be gendered (Capobianco, 2006; Capobianco, French, & Diefes-Dux, 2012; Meyers, Ohland, Pawley, Silliman, & Smith, 2012; Tate & Linn, 2005). These studies collectively demonstrate the usefulness of identity in understanding individuals' commitment to, and experiences in, engineering.

WOMEN ENGINEERING STUDENTS IN JAPAN

In Japan, despite a recent decline in popularity, engineering students comprise roughly a third of undergraduate students in the national university sector (MEXT, 2010), which admits academically well-prepared students. The relevant features of Japanese engineering education are summarized as follows. Firstly, women are scarce among engineering teaching staff. Despite the recent effort to increase the number of women researchers and professors in STEM (BCSTP, CO, GJ, 2011), the proportion of women was only 3.8% in 2007 nationally, which is much lower than that found in all fields of study taken together, which is 13.0% (NISTP, 2012; MEXT, 2010). Secondly, courses are taught mostly by departmental faculties who have strong research orientations. Despite strong calls for change, the lecture style of instruction still dominates college-level classes and the use of teaching assistants to support learning is not yet common (Central Education Council, 2008). Finally, there is a marked difference between the first three years of study when students take classes as a cohort; and the last year when students engage exclusively with research units consisting of academic staff, graduate students, and final-year students for their capstone projects. Training in the research units has been more emphasized than coursework in engineering education. Because of their commitment to research units (Arai, 1989) and the hierarchy among higher education institutions, engineering graduates rarely move to other institutions for their master's degrees. In the national university sector, in which 66% of men and 44% of women graduates–pursue a master's degree, more than 80% of first-year master's students were graduates of the same institution (MEXT, 2010).

A few studies provide a glimpse of women's experiences in engineering in the Japanese context (Hosaka, 2010; Kawano, 2007; Koinuma, 2009). For example, alumnae of an engineering college identified 'special treatment' as the biggest source of their dissatisfaction with the college (Koinuma, 2009). Another study of female engineering graduate students reported that their integration into the department finally occurred in their research units, where they experienced some difficulty adapting socially to a male-centered community (Hosaka, 2010). When choosing their units women in the study took into consideration not only the research areas, but also their perceptions of the chair's management style and personality. Contextual information and existing studies suggest that positive experiences with predominantly male faculty facilitate Japanese female engineering students' decisions to pursue master's degrees and enhance their integration into the department and their development of professional identity.

THE PURPOSE

The purpose of this exploratory study is to describe the experience of women engineering students in Japan as they interact formally and informally in academic settings with faculty in their areas of specialization. Because of the differences in learning environments and faculty roles in students' learning between the years of their coursework and their final year in the research unit, only experiences from the first three years of study (both classroom experiences and out-of-classroom

contacts with faculty for academic problems) were examined. Data were collected from interviews with women beginning their final year of engineering study. At this point, it is expected that participants had gained insights into both their past experiences as well as the direction they plan to pursue after graduation.

It seems appropriate to study women's experiences separately from men's because the existing literature shows gender differences in student–faculty interactions in general and students' experiences in engineering specifically. Also, using the qualitative method seems warranted, considering our limited knowledge on the topic, especially in Japan. The following research questions guided the study:

1. How do women engineering students in Japan perceive their experiences with departmental faculty?
2. How do women engineering students perceive the relationship between their formal and informal experiences with departmental faculty? In other words, what role do classroom experiences play in students' interactions with departmental faculty outside the classroom, and vice versa?
3. How are women engineering students' experiences with departmental faculty different according to their postgraduate plans?

This study uses the theory of role as resource (TRR) (Baker & Faulkner, 1991; Callero, 1994) as the theoretical framework, following Collier's (2000) study of students taking a course designed to enhance institutionally promoted college student identity. In Collier's study, participants were studied for possible correlations between changes in their college student identity and their matriculation status. This study compares the nature of the student-faculty interactions of final-year students who have different postgraduate plans. Its underlying assumption is that individuals with different levels of professional identity, although they share the same gender, might engage differently in identity-related behaviors. However, this study does not examine the impact of such behaviors on students' postgraduate plans or the nature of the engineering identity itself.

THEORETICAL FRAMEWORK

TRR was derived from identity (role) theory, which conceptualized the self as an entity with multiple roles or identities based on a structurally constrained relationship with others (Stryker, 1980). This sociological theory takes the perspective of structural symbolic interactionism; this theory maintains that while social structure determines the social positions of individuals, individual agency enables changes in social positions. TRR divides the concept of identity into *role* (claimed identity) and *status* (acquired identity) to emphasize this dualism. The theory asserts that a role should be first claimed by the actor and then enacted into a status using the 'role' as a resource. Through this process, individuals gain new resources (acquired resources), which can be used to facilitate the achievement of a status (Callero, 1994). Because agency determines the extent to which

individuals with a certain identity use their roles, the extent of individuals' acquired resources and developed identity will consequently vary.

In the context of this study, TRR treats student–faculty interactions as behaviors related to engineering student identity. It distinguishes the state of being a student from the state of becoming a student. Thus, TRR can help us understand the important role of student–faculty interactions in individuals' postgraduate decisions. First, individuals in engineering programs are considered to hold an engineering student's role. The use of this role (e.g. taking classes and asking questions) enables individuals to obtain new resources (such as knowledge and skills) and facilitates their becoming engineering students, graduates, or even engineers in the future. Students' postgraduate decisions can be conceptually viewed as the result of an accumulation of identity-related behaviors over the years. Thus, engagement in active and effective behaviors related to engineering student identity are considered to positively affect students' persistence and choice of professionally oriented paths after graduation.

METHODS

I conducted in-depth, semi-structured individual interviews in Japanese. Ten open-ended questions and additional follow-up questions were developed from a literature review on graduate education participation and persistence in the STEM fields.

Participants

Participants were 32 final-year women engineering undergraduate students at two moderately selective national universities in Japan: Western University and Central University (pseudonyms). Participants were recruited purposefully (Patton, 1990) through the selection of the institution and the timing of the interview to inform a larger study, of which this study is part. The larger study examines the contribution of women engineering students' experiences in their major departments to their decisions to pursue graduate education in Japan.

Engineering schools at the two universities admit roughly 500 full-time students each year and share many important characteristics, including women's representation both as students (13.5% at Western and 12.0% at Central) and faculty (4.7% and 1.0%) and the proportions of female graduates who continue immediately to a master's degree program (35.7% and 37.7%). The latter rates were much lower than those of male graduates at these institutions (61.1% and 73.3%). By recruiting participants from two schools, I intended to eliminate the possibility of unintended bias stemming from an institution-specific context (Yin, 2003). The interviews were conducted in 2009 a few months after the start of the academic year to ensure that participants' perceptions had not been influenced by their recent experiences in research units. Participants were expected to have already decided on their postgraduate plans by the time major firms had completed their recruitment of prospective college graduates and graduate programs had started the admission process.

Upon receiving their permission to recruit students, I asked the deans of these engineering schools to contact all female final-year students via e-mail. The e-mails stated that the purpose of the study was to understand the contribution of experiences in a major department to the decisions of female Japanese engineering students to pursue graduate education. Due to the schools' involvement in recruitment, I assured prospective participants in writing that participation was voluntary and that the contents of their interviews would not be published or shared with the school in a form that identified individuals. All female students who volunteered were interviewed, including 19 students who planned to continue to a master's degree program (10 from Western and 9 from Central). While Western participants (17) came from six departments, Central participants (15) came from the two departments that had the largest and second largest proportion of women (applied chemistry or bioengineering). Participants were all unmarried and of college age.

Data Collection

In each session, I obtained informed consent, interviewed for 50 to 60 minutes, and conducted a member check, a procedure that enhances the credibility of the qualitative study (Lincoln & Guba, 1985). At the beginning of the interview, I asked participants to introduce themselves by sharing their overall college experiences, postgraduate plans, and career goals. I then asked participants about their academic experiences, focusing on their interactions with other members of the department, including faculty. Finally, I asked participants about their experiences of making decisions about postgraduate life and their expectations for the rest of their final year and beyond. Only towards the end of the interview did I ask participants whether and how they perceived the role of their overall collegiate experience, to avoid sensitizing participants to the potentially sensitive issue of gender in engineering.

Data Analysis

Although my research questions initially offered categories for analysis, data were analyzed inductively by use of constant comparative methods (Glaser & Strauss, 1967). The data were systematically coded after key themes describing the participants' experiences were identified. The findings were then compared to students' postgraduate plans.

Following Lincoln and Guba's (1985) recommendations, four criteria for the trustworthiness of the study were considered: credibility, dependability, confirmability, and transferability. To enhance credibility, I used member checks and systematic coding. All records, including interview notes, have been kept as an audit trail to ensure dependability and confirmability. I provided the detailed written descriptions of the participants' experiences. I conducted peer debriefing with a Japanese researcher who conducts qualitative research. My graduate advisor provided me with feedback. As for transferability, I cannot claim that the experiences of this study's participants—although adequately reflected—can be directly applied to women in other universities within and outside Japan. Further

qualitative and quantitative work must be conducted to confirm if the findings of this study hold consistently across universities within and outside Japan.

FINDINGS

In the following section, I describe the participants' perceptions of their experiences with departmental faculty. In order to protect the participants' anonymity, I use pseudonyms with institutional names and codes representing the participants' postgraduate plans at the time of interview: "Work" for obtaining a job and "Degree" for pursuing a master's degree. I will occasionally use quantifiers, such as many and most, to help readers have a sense of the prevalence of the phenomena discussed.

Inside the Classroom: Development of Psychological Distance

Classroom interactions, which formed the central part of faculty contact for all participants, were not very positive. Participants were generally unsatisfied with the quality of teaching in engineering, in which instructors taught to a specific syllabus following a textbook. In classes that participants targeted for criticism, instructors explained the material without regard for students' levels of understanding. Under this one-way instructional method, participants sometimes took notes for future study without understanding what they were being taught. Participants remained silent even when they had questions. They observed that only a few "smart" male students spoke up in class. Although students varied in how they characterized the classes in their programs, they reported it was common to experience problems with the instructional methods. They attributed their conceptual difficulties or sense of ineptitude in their classes to poor instruction. Only a few participants who planned to pursue their master's degrees were not bothered by specific instructional methods. In the rare classes that students liked, an instructor presented material step by step and occasionally offered students demonstration and hands-on learning opportunities.

In describing individual differences among professors, Kazumi (Degree, Central) shared her observation of poor teaching and its consequences for her learning:

> *An example of a class where I would question the quality of the teaching was the class in which an instructor wrote equation after equation on the blackboard. He didn't take questions on what he was teaching or explain the equations he wrote. When I reviewed my notes, I had no idea what we had learned. I had a hard time preparing for examinations in his class.*

Participants inferred that this one-way instructional method reflected not only the instructor's poor teaching skills but also a lack of interest in student learning. Participants perceived that instructors, although they claimed to respect students' independent judgment regarding their study practices, did not know students' capacity for understanding and wrongfully assumed that all students should be able to master the material. To participants, the responsibility for productive student learning rests, at least partially, on the instructors. Another Central student

(Degree), Yoko, reported that professors in her department generally ignored students' misbehaviors (such as napping in class and sneaking out of the classroom) and taught difficult material only to "smart" students. She shared her feelings of alienation:

> *When a professor taught the class without preparation or paid little attention to what he was doing, we didn't understand the class at all. Well, we were kind of bored [because we did not understand what we were learning]. There was nothing to do during the class hours. It means that professors didn't teach students. They only talked about what they knew.*

Participants had gained a vague idea of what the college-level teaching would be like from contacts outside the field such as siblings and friends. Because of their limited experience with classes outside their major, however, participants were unable to identify the exact problems with their classes or define poor teaching specific to their programs. They only criticized the attitudes of departmental faculty in comparison to their high school teachers:

> *In college, professors teach in a way that [implies] they don't care whether we understand. They say it's our fault that we don't understand because we don't listen attentively to what they are saying* (Ikue, Work, Central).

Outside the Classroom: Little Interactions with Faculty

Contact only when necessary.

Although almost all participants had contacted instructors in their programs outside the classroom, the frequency of these contacts was generally low, less than once or twice a semester. Participants could count all the occasions they contacted professors, including brief contacts such as receiving graded reports.

Students initiated contact with instructors primarily when they had course-related questions, especially on fundamental topics. Most participants had first posed their questions to their friends and then to other students they knew less well. They approached their instructors only as a last resort when no one else could provide an answer. Some participants avoided contacting instructors altogether and left problems unresolved when they considered them unessential or not urgent (e.g. when they knew other students did not understand the material either). Only a few participants visited professors for substantial discussions about their study or careers. Few took advantage of the required regular opportunities to meet with a faculty advisor.

Unapproachability of the faculty.

The students' reluctance to contact faculty was widely attributed to the gap in social status between students and faculty: participants seemed to believe it inappropriate for undergraduates to initiate contact with busy, important professors except when they had serious concerns. The observation that professors were rarely in their offices also discouraged many participants from visiting them, yet no one explicitly mentioned that gender was an issue. For example, Megumi (Degree, Central), who

preferred her friends over instructors for course-related questions, offered the following frank sentiment:

> *First of all, I didn't want to visit professors frequently. Professors are professors. Their duties involve many things other than teaching. I didn't like to go all the way to a professor's office alone. When I had to, I wanted to finish my business as quickly as possible.*

Students confirmed experiencing a psychological distance from their instructors, although the extent of this distance varied among participants according to their individual classroom experiences. Naomi (Degree, Central), like many participants, commented on professors' approachability: "*There were two types of instructors: those who seemed to be approachable and those who seemed to be saying 'Do it by yourself.'"* When a professor showed a welcoming attitude in class or verbally encouraged students to ask questions anytime, students felt encouraged to visit him for help. It was more typical, however, for participants to feel discouraged from exposing their lack of understanding to professors by asking questions because they perceived a high standard of expectations from the attitudes and comments in the classroom: "*I felt embarrassed because I asked the professor questions about the material he had already taught, admitting that I did not understand".* (Tomoko, Work, Western.)

Participants also learned about individual professors' approachability from other students. In fact, students shared their individual experiences with one another and used this information to decide whether they should approach a certain professor or professors in general. For instance, after hearing that a professor addressed a demeaning comment such as "I don't believe you don't understand such an easy matter" to a friend of hers, Hatsu (Degree, Western) rationalized that an office visit was unnecessary: *"The professor might have answered the questions if I asked him. However, it was hard for me to go to the professor's office. I wondered whether I should ask such a trivial question."*

Need for different strategies.

When participants decided to ask questions after they concluded they had no other options, they used a variety of strategies for approaching faculty with their academic problems. In addition to their perceived psychological distance from faculty, their level of understanding seemed to determine the strategies they chose.

Participants most commonly went with peers to ask the professors questions. Fortunately, finding company to visit a professor's office was natural for study participants because they typically studied in groups that were almost exclusively female. Many students' contact with professors outside of class were thus actually limited to this type of meeting. This strategy was available regardless of students' level of understanding and gave legitimacy to their need for academic help. Yet, there were participants who only used this strategy if someone asked them to go or if they faced the threat of failing the course.

Participants also visited faculty individually. Not surprisingly, participants who planned to pursue master's degrees usually approached faculty with questions individually. They also typically studied alone or studied with their friends only for social reasons. These students prepared for their meetings thoroughly before approaching professors so they could explain properly what they did not understand. This preparation enabled them to obtain academic help effectively without giving the professor the impression that they had no understanding of the subject. While this provided students with good learning opportunities, contacting professors individually seemed to require students to feel more confident of their understanding of class material than asking questions with their friends:

> *I wanted to be able to explain what point I didn't understand, such as "I've been trying to solve the problem this way, yet I still don't understand this point." Otherwise, I wouldn't be able to understand a professor's explanation when I asked him* (Kei, Degree, Western).

Different Consequences of Student-Faculty Interactions on Students' Learning

After evaluating their needs and other concerns, participants concluded only rarely that they should seek assistance from the faculty. When asking professors questions outside the class, participants often found these encounters satisfying despite their negative preconceptions about such meetings. They perceived that instructors communicated with them more frankly in individual settings than in the classroom, and found their understanding of subject matters improved through these contacts. For example, Saki (Degree, Central) was surprised that a professor, who usually taught classes mechanically— as if he believed an instructors' responsibility was merely explaining the method to solve problems—taught her step-by-step, showing his interest in her understanding. Madoka (Degree, Western) found it interesting that a professor asked her opinion about the reason for the low student enrollment in his early-morning class when she visited him for a question.

It is thus not surprising that the participants who interacted relatively frequently with faculty typically started asking questions early in their academic careers and became comfortable approaching professors at some point in their first three years of college study. Some students asked instructors questions immediately after class or made it a habit to clarify their questions as quickly as possible. In fact, they sought advice on highly field-specific issues, including the implications of skipping a grade or pursuing a master's degree at a more prestigious institution, as well as feedback on their fitness for the field. These students generally felt that professors knew them well; thus, they seemed relatively comfortable approaching faculty with their questions. For example, Yayoi (Degree, Western), who initially thought it "scary" to approach professors, "who looked grand and different from high school teachers," stated *"Professors gave me the best advice. My friends didn't know the answer. Graduate students didn't know everything. My parents didn't know much."* However, even these students contacted only a few specific individuals when the conversation would involve topics that were not course related, reflecting their reservations about faculty members' general approachability.

Academically constructive interactions, however, did not seem to affect most participants' attitudes toward faculty contacts. Most participants continued to approach faculty only when they needed to, and simply stopped asking questions after their understanding improved.

DISCUSSION AND IMPLICATIONS

To summarize participants' experiences, this study's findings indicated that women rarely interacted with faculty outside the classroom mostly because of their poor classroom experiences. Feeling ignored by instructors who taught difficult material poorly, the women were critical of their instructors and felt ashamed of their own lack of understanding. When necessary, the women pursued various strategies for seeking faculty assistance with academic problems; these strategies varied with their levels of academic understanding and comfort approaching the faculty. Because participants found instructors helpful in actual individual encounters, the choice to contact faculty outside the classroom increased the individual differences between those who sought help and those who did not.

This study's findings on poor classroom experiences and infrequent faculty contact that were mainly course-related are generally consistent with previous research (Cotton & Wilson, 2006; Meyers et al., 2012; Seymour & Hewitt, 1997). Although the women themselves should become more assertive to request the change in teaching practices or ask questions, the findings suggested that teaching in the two engineering schools examined in the study appeared to be ineffective. Because the literature has suggested that both good teaching practices and student–faculty interactions positively impact students' educational and career aspirations (Colbeck, Cabrera et al., 2001; Kuh & Hu, 2001; Pascarella et al., 2004; Sax, 2001; Sax et al., 2005), possibly by fostering increased levels of academic confidence and self-efficacy, it is disturbing that these findings showed otherwise.

Further, the findings that suggested women's experiences within and outside the classroom were interrelated, although this study did not examine the size of the effects, are consistent with the literature on student-faculty interactions in general. On the one hand, what students experience in the classroom formed their interactions with the faculty. Research has reported that students' academic performance (e.g. grade) (Cole, 2010; Kuh & Hu, 2001) and their perceptions of their classroom experiences (Cole, 2007; Cotton & Wilson, 2006; Wilson et al., 1974) influence the frequency and nature of their interactions with the faculty.

The findings suggest that the students most likely to suffer from poor teaching practices were those who rarely approached professors despite their need for academic assistance. By contrast, participants who perceived little problems with approaching professors seemed to have the confidence to explain their problems. Participants' reluctance to approach professors stemmed at least partly from embarrassment about revealing their ignorance to their instructors, whose approachability students found varied. This fear or avoidance of faculty contact has

been explained in the literature as college students' unwillingness to reveal their weaknesses (Seymour & Hewitt, 1997) or to be singled out and required to work harder (Cotton & Wilson, 2006). Considering the Japanese context, in which engineering students engage in a capstone project in the research unit and are likely to continue their master's program internally, participants understandably felt the stakes were high.

On the other hand, participants did report positive individual contacts, which resulted in better understanding of the subject matter and helped students overcome their difficulties in approaching the faculty. It is unclear whether the out-of-class contacts directly influenced students' classroom experience. The findings from past research demonstrated positive outcomes from student-faculty interactions, including grades, academic self-concept, and attitudes toward learning (Cole, 2010; Cotton & Wilson, 2006; Sax et al., 2005). Thus, it would be safe to assume that students benefited from these contacts.

This study's significance is its use of the TRR, which interprets students' infrequent faculty interactions and individual differences as the failure to acquire resources through role use. Firstly, infrequent out-of-class contact could be explained by TRR as individuals' failure to obtain a resource through their role use in the formal classroom setting. Although women attended classes as they were expected to in their role as engineering students, they did not effectively use their roles to obtain additional resources, such as a good understanding of the subject matter and the comfort they felt about approaching professors. Because students were in a position to decide whether they needed to initiate out-of-classroom interactions, their negative response was thus a natural consequence. It is regrettable, however, since such interactions could have produced additional resources unavailable in formal instructional settings, and facilitated future contacts and subsequently, achievement of status or identity.

Secondly, the findings suggest that the participants' differing experiences within and outside the classroom could be explained by TRR as the differences in role use and resources obtained. Because this study relied solely on self-reported data, it can only make limited claims about their differing amounts of resources. The use of objective data, such as academic records, would be necessary to confirm these differences. The perceptions of instructors who have worked with the students should also be explored; they could provide useful insights on how students used their roles and resources differently and how their levels of understanding and their comfort interacting with faculty, interplay in their interactions.

I did not observe any clear distinction between the experiences of students with different postgraduate plans, except that those who planned to continue their master's programs were generally independent learners and the few individuals who did not report problems with instructional methods belonged to this group. It seems odd that seniors who planned to pursue graduate education did not necessarily consider their educational experiences positively, since the intent to pursue a master's degree likely stemmed from a strong engineering identity. A

possible explanation might be that students planning advanced study have compensated for a lack of resources stemming from poor role use by other means. Using peers' help may be an example of the means presented in this study (Cole, 2007; Lundberg, 2003; Tate & Linn, 2005). Another explanation might be that seeking to contact the faculty might not be the kind of activity that participants considered appropriate for college students (Cotton & Wilson, 2006). This study was limited to examining only student-faculty contacts for academic problems as identity-related behaviors. Future studies should explore identity-related behaviors more broadly, since students with different postgraduate plans may differ more clearly in other identity-related behaviors as well as in the resources they had prior to college or obtained through these behaviors. Researchers should also examine the relative importance of different types of resource in role use and how students compensate for the lack of one resource by using another.

The study found that the participants attributed their poor classroom experiences to instructors and remained unwilling to contact instructors they found unapproachable. These findings indicate the key role instructors play in female engineering students' role use. It is not possible to conclude from this study that the observed experiences are gendered because it did not compare women's experiences with men's. Whereas no participants explicitly claimed that their gender or that of their professors played a role in their interactions, consistent with the findings of Powell et al. (2011), participants in this study noticed that instructors behaved differently in individual encounters than in the classroom, in which the majority of students were male. It remains to be examined whether this stems uniquely from the male-oriented engineering culture. However, since studies that examine women's experiences in male-dominated STEM fields, including engineering, have found that women's experience is different from that of men's (Baker, et al., 2002; Seymour & Hewitt, 1997), it is reasonable to suspect that participants' experiences were at least partially gendered.

The absence of recognition of the gendered nature of their interactions with faculty might be due to the lack of direct interactions, which were more likely to occur in field-specific, hands-on learning environments (Du, 2006; Powell et al., 2009). This also might be due to the lack of comparable individual contacts with female faculty or non-engineering faculty whom women students have better interactions (Nadler & Nadler, 2001; Seymour & Hewitt, 1997). In addition, the interview design might not allow participants to reflect fully on gender factors in their interactions with faculty. Despite the absence of such claims, it is still noteworthy that participants in this study volunteered to report their troubling experiences in formal instructional settings that seemed to inhibit their learning. Researchers should continue to investigate the role of gender in female students' interactions with faculty. In addition, future studies on women's experiences probably would benefit from including men's perceptions of women's experiences as well as input from instructors.

This study is methodologically limited because of its reliance on final-year students' reflections on their experiences over three years or more. However, it is possible that the participants, who were seniors, perceived their experiences more positively

at the time of the interview than they had previously due to gains in academic confidence (Colbeck et al., 2001; Vogt et al., 2007) and recognition of the value of student–faculty interactions (Cotton & Wilson, 2006; Kuh & Hu, 2001). In future studies, researchers should consider interviewing students in earlier years of study while their experience is current. Also, longitudinal studies would reveal classes and stages of the curriculum critical to women's identity development.

A few practical implications can also be drawn from this study's findings. Engineering professors, who are hired for their research accomplishments, typically lack training as teachers, and thus, need resources and opportunities for professional development to become better teachers. Because at least one study showed that different teaching practices contribute to men's and women's confidence to pursue engineering careers (Colbeck et al., 2001), professors in engineering should be more conscious of women's different needs. Instructors also need to become more cognizant of students' perceptions of their teaching practices and attitudes in class, including the perceptions of women students. Amelink and Creamer (2010) reported that women in engineering are more likely than men to value the interpersonal dimensions of the classroom experience, including respect from faculty and faculty concern for students' learning. Since poor classroom experiences impede positive out-of-class interactions and, subsequently, the development of engineering identity, instructors' intentional efforts to teach effectively, including helping students understand the content and encouraging them to more actively engage in their learning, might be necessary.

Students themselves should be taught to become more independent as learners. Engineering schools should teach students, especially female students, as soon as they start an engineering program how to become successful in the field. Given that some participants, who overcame their initial reluctance to approaching professors, benefited from the interactions with instructors, these efforts to help women students become active learners seems worth trying.

CONCLUSION

Although much research has been conducted on women's experiences in engineering, this study demonstrates the utility of the TRR, particularly the concept of resource, in understanding women's experiences and the interplay between multiple behaviors that explain identity development. Researchers should consider identifying identity-related behaviors that are critical to the development of engineering identity. This study provided additional evidence that women's perceptions and interpretations of their classroom experiences in engineering were generally negative, but diverse. Although much has been reported on women's gendered educational experiences in engineering, we still need to investigate further female students' interactions with the faculty.

In addition to providing support for previous research, this study offers new evidence from the Japanese perspective and broadens our understanding of women in engineering by using the TRR as its theoretical framework. The transferability of

this study is contingent upon researchers and practitioners identifying findings that may be relevant for their settings and the particular female students there. This study was conducted in a society where engineering students engage in research experience as members of research units and choose their alma mater for their graduate study; thus, students' relationships with faculty are expected to play an important role in their choice to pursue a professional career that usually requires a master's degree. Universities in Japan are making efforts to increase the number of women who major in engineering. However, the focus should also be on the retention of female students through an improved learning environment.

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