Work & Play in the Geotechnical Lab: Gender Implications for Engineering Educators

Corri ZOLI
Syracuse University, 008 Hinds Hall, Syracuse, NY 13244, cbzoli@syr.edu

Jennifer SMITH
Syracuse University, 008 Hinds Hall, Syracuse, NY 13244, jlsmit06@mailbox.syr.edu

Shobha BHATIA
Syracuse University, 230 Hinds Hall, Syracuse, NY 13244, skbhatia@syr.edu

Tej BHATIA
Syracuse University, 312 HBC, Syracuse, NY 13244, tkbhatia@mailbox.edu.syr

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ABSTRACT: *In this three-part paper, we bring feminist insights about gender and education into the educational site and case study of the geotechnical engineering lab at Syracuse University, a large private research university in upstate New York. Our paper is structured into three sections: (1.) Feminist Education Theory & Engineering; (2.) Qualitative/Observation Study of the Geotechnical Lab; and (3.) the Role of Learning Contexts in Improving the Success of Women in Engineering. After providing a focused theory review of feminist accounts of education in the context of post-secondary science and engineering, we describe through qualitative analysis the results from observations conducted on the gendered behavior and interaction of students in the undergraduate geotechnical engineering laboratory (lab). We then situate these observations in the larger institutional context of Women in Science and Engineering Programs (WISE) and their role in college/university culture change from the vantage point of a senior female scholar in the field with over 22 years of engineering teaching experience and women's advocacy. We specifically address the educator's role in improving pedagogy, mentorship relations, and types of classroom experiences for engineering students. In general, we found that underlying gender ideologies and interactive practices can be addressed pedagogically to alter and enrich participants' experiences in the science and engineering curriculum.*

1 FEMINIST EDUCATION THEORY IN ENGINEERING

In Gender Play (1993), sociologist Barrie Thorne observes the role of "gender play" in U.S. elementary school interactions between boys and girls in class and in school-related games and activities. Through careful observations, she reveals how broader social and gender norms, including ritualized power roles, are "played" out by even very young students. Part of a broader set of feminists studies of gender and education that includes such ground-breaking work by Carol Gilligan, Deborah Tannen, Lynn Weber, and Christine L. Williams, Thorne helps us to see that even in the least serious activities, such as "play," gender as a social process is present – though one, especially in the educational environment, that is open to transformation and change.

Over the last twenty-five years, studies of science and engineering education show the reality of gender, if less often "gender play," in several ways [NSF, 2002]. Most obviously is the well-documented problem of the under-representation of women and minorities in science, technology, engineering, and mathematics (so-called STEM fields), especially at that gateway moment of post-secondary education. Problems studied include: (a.) recruitment, student persistence and retention issues (Strenta et al., 1994; Fenske et al., 2000); (b.) gendered modes of communication style (Ingram et al., 2002); (c.) the "quantitative feminisation" of fields or "getting in" instead of "vertical feminisation" or "getting on" by achieving upper-level success (Glover, 2002; Bebbington, 2002 p. 363); (d.) cultural attitudes and expectations based on social stereotypes, including the scientist/engineer as male (Beder, 1998); (e) the family or motherhood demands in a segregated labor force (Husu 2001); (f.) barriers, biases, and abuses in the work environment in academia and industry (Bagihole et al., 1995; Morley 2002; Glover 2002); and (g.) women's preparedness, confidence, self-esteem, and/or feelings of isolation, exclusion, and alienation.

As most educators know, however, despite much effort – including over 90 million dollars invested in STEM education programs by the National Science Foundation (NSF) alone since 1993 – recent data reveals that numbers of women achieving degrees in STEM fields has not changed, that it may have peaked at 37 percent in 1984, and since declined to 28 percent in 1999-2000. This picture is even more bleak in engineering (Leslie & Oaxaca, 1997; NSF, 2002). As Sue Rosser writes of the "two way street" between women's studies and "scientific literacy" research in a recent essay:

Despite the apparent positive impact of feminism, Women's Studies and the women's movement have remained relatively impermeable in breaking the obstacles to women's entry to law, medicine, business, and almost every other profession, the physical sciences and technological fields. Although women have penetrated in increasing numbers the biological and social sciences, the numbers in the physical sciences, engineering, and computer science have actually reached a plateau or decreased in recent years (107).

But Rosser also goes on to argue that the important collaborations between women's studies and science and engineering education research offer more positive outcomes than mere numbers indicate. These collaborations over the last 25 years have changed the shape of science and engineering, its education and study, she argues, and prompted paradigm shifts that range from increased awareness of gender and diversity in improving education for all students to questioning the social role of science (Brown, 2000; Ginorio, 2000).

We therefore explore in this paper, following from Barrie Thorne's evocative metaphor of " gender play" and drawing from Sue Rosser's sense of the positive role of gender for STEM education research, how the undergraduate engineering classroom offers multiple opportunities to see gendered behavior at work. But we also approach gender in the engineering classroom with an open mind: as both a hamper or constraint on women's learning and success, as many studies have shown, but also as a site of possibility and "play," a means to promote innovation and reform in STEM education and in the social role of science and engineering more generally. Indeed, while approaches to gendered behavior in the post-secondary engineering and science classroom have ranged on specific aspects of the problem, "life-sequence" accounts of key social-psychological issues such as "self-concept/self-efficacy, peer influence, and goal commitment" in early development (Leslie et al., 1998) to a male-dominated engineering culture to which women must adapt to succeed, we have witnessed multi-layered gendered behavior, including changes over time.

To construct a wholistic and complex model of understanding the role of gender in the engineering classroom, we adapt feminist qualitative research methods, including participant observation and discourse analysis, to the engineering laboratory. Likewise, we eschew the so-called "deficit model," which faults women's preparedness, aptitude and competency in STEM fields [Byrne, 1985; WISET 1995], and turn instead to understanding what has been described as a prevailing masculinist environment of work and study in engineering. Feminist education theory offers feminist concepts of gender to understand women's performance in certain male-dominated environments as informed by structures of power, authority/success dynamics – not their own "personality traits" [Dabke, 1995; Duane 1995]. Moreover, if "gender" is a socially, culturally, and contextually-constructed set of rules and conventions not a biologically predetermined state of being, and if the STEM educational environment is a kind of culture, to transform it into a more gender neutral one requires culture and behavior change, both premised upon an awareness of the role that participants play in their gendered behavior at all levels of this environment.

By witnessing gendered play in work-groups in the engineering laboratory which we then compare to a "long-gaze" on changes in gendered behavior from the perspective of a senior educator and scholar, one can see that such gendered behavior codes are learned and entrenched, and supported by a particular climate and classroom structure. The can be unlearned, played with, or transformed when necessary, especially with the help of well-meaning faculty, peers, and mentors interested in enlarging the educational experience for all students. Indeed, learning new models of gendered behavior and new interpretations of one's gendered identity is part and parcel of the experience of engineering education.

2 QUALITATIVE/OBSERVATION METHODS: DATA COLLECTION FOR A LONG-GAZE

2.1. TWIN SITES OF ANALYSIS: SHORT & LONG-TERM DATA

Qualitative and discourse analysis were used to study the behavior and interactions of students in the undergraduate geotechnical engineering laboratory (lab) at Syracuse University (2001) – including participant observations, interviews, and transcripts from undergraduate-student lab participation over the course of a semester. We also relied upon a second less formal data source: the anecdotal information and observations conducted by a senior engineering faculty member at Syracuse University, one of the few women in the Department of Civil and Environmental Engineering, over a fifteen-year period of teaching in engineering classrooms. While these studies represent preliminary findings whose results cannot be generalized, we combined "short" intensive and "long" generalized comparative perspectives on engineering education so as to explore both the status of cultural gender assumptions over time and further to factor into analysis that storehouse of knowledge and observations about gender in the engineering classroom incorporated into a successful teacher's pedagogy, often simply termed "experience."

Data Site 1:

The first lab study was conducted over one semester (2000) of three different geotechnical engineering lab groups: it consisted of six observations and two unstructured interviews. The data was also enriched by observing several different groups in the lab: one lab was observed three times, a second lab was observed two times, and a third lab was observed one time.

Data Site 2:

The second set of observations was informally collected from undergraduate and graduate Civil & Environmental Engineering classrooms over a 22 year teaching period at Syracuse University (1980--) by an active, senior scholar and educator recognized for her innovation and excellence in gender and diversity in pedagogy.

2.2. Engineering Lab as a Rich Site of Gendered Interactions

Studies on gender dynamics in the engineering classroom still represent a gap in the scholarship – even though recent essays, theses, and reports are documenting a rich venue for observing gendered behavior and complex interactions of all kinds with a bearing on learning outcomes and proportional representation in academia and the profession [Stronyer, 1997; Burrowes 2001; Persuad, 2003; Gravel et al., 2003; Agogino, 2000]. Engineering classrooms frequently consist of only 20 percent or less (the national average for women in the engineering classroom is 16 percent) female students. Likewise, they include an ethnically and nationally diverse student body, both undergraduate and graduate, including many international students. While this lack of parity alone may indicate a site rich in gender dynamics, studies have shown that beyond the "chilly climate" of STEM fields, engineering is an especially challenging masculinized culture – with its "hard" and competitive atmosphere, "weeding out" practices, and stereotyping [Persaud, 2003; Seymour, 1992; Sandler, 1982; Seymour & Hewitt, 1997, Murray et al, 1999; Byrne, 1994]. Indeed, the structures of the engineering educational experience and the culture of the disciplines are often antithetical to learning contexts in which women excel, such as cooperation (Tonso, 1996).

The lab, however, because it is only a semi-controlled environment, less rigidified than the engineering classroom and often facilitated primarily by teaching assistants (TA's), allows students, while they must complete experiments and tasks, to preserve a degree of autonomy distinct from the seminar/lecture classroom. This less-structured environment encourages peer roles and interactions and thus offers a different venue in which students occupy a comparatively larger and more active role in establishing work relations on their own terms. This process includes both inhabiting existing cultural gender norms in interacting with one another, but also adapting gender norms for the specific engineering context – a place which may allow students, mentors, TA's and faculty to change, disrupt, over-turn, or play with such norms. To return to Thorne's evocative notion of "play," one of our central observations of the lab includes the realization that students are not only engaging in work-related interactions, but in doing so, they "played" with their identities as woman and men, students, team members, and engineering majors/minors.

2.3. Participant Observer or Informed Witness?

Qualitative measurement – unlike quantitative research – depends upon, as Abraham Kaplan observed in The Conduct of Inquiry, a view of scientific research as a fundamentally human, social activity (p. 4. 1964). Qualitative research is an umbrella term for certain shared research strategies in the social sciences to deal with "soft" or rich data such as conversations, descriptions of people or places that does not lend itself to statistical analysis and a fundamental emphasis on the subject's own frame of reference in context, not external causes (Bogdan & Biklen, 1982, p.2). As Gunilla Burrowes astutely notes, there is a need to broaden the scope of research tools in engineering "to incorporate the human elements of technology" and to use research methods that "reflect the multiple realities and subjective experiences of individuals" (p. 9. 2001). Burrowes goes on to argue that "the scientific approach is unable to do this with its emphasis on a social reality that is objective and external to the individual, with a goal to identify or isolate the 'truth' rather than to find and clarify meaning within an environment" (p. 9). Qualitative data collection methods use case studies, structured or unstructured interviewing, archival or additional supplementary data, fieldwork, direct and participant observation, and others.

"Participant observation" in the social sciences and education theory is typically defined as deep immersion – the researcher becomes a member of the culture or context observed to conduct analysis from this subjective/insider perspective. The researcher can be a full, partial, or outside observer; explain or conceal her role; conduct one or multiple sets of observations; focus on single variables or seek holistic analysis by letting variables emerge ("grounded theory"). In our case, we sought to develop a modified form of participant observation data collection to take into consideration the experiences of two of our authors who have participated in this lab, as both students and instructors.

We sough to examine students' gendered interactions from the perspective of a non-participant, but informed "witness" in a familiar environment. By "witness" we mean to develop a category that describes the positionality of the researcher that lies somewhere between the binaries of "participant" and "non-participant observer." In this case, the "witness," like a participant observer, is familiar from direct experience with the environment of the engineering lab, its codes, rules of behavior, culture and activities – in some cases, she had taken an authority position for constructing this environment. What distinguishes the "witness" from a "participant observer," however, is her efforts to separate herself from the activities and relationships occurring in the classroom, even while she is inevitably implicated in them in her very presence and in students' awareness of it. Such an analytical separation of the facilitator's authority is especially imperative for women undergraduate engineering students to develop their own terms of authority.

Moreover, this familiarity and authority had advantages in analyzing gender in the engineering lab in a way best described by anthropologist Clifford Geertz's term "thick description." In The Interpretation of Cultures, Geertz argues that the goal of the ethnographer is to observe, record, and ultimately analyze a culture. To do this, requires interpreting signs to gain their meaning within that context/culture. Interpretation itself, however, is predicated upon four conditions: (a.) intelligibility of the culture/context to the observer; (b.) his/her understanding the formal rules of use and content of its codes; (c.) deciphering how power dynamics shape meaning (e.g., a female student's persistent helpfulness to men in a work-group in the context of gender power relations may signify something other than her mere goodwill); and most importantly, (d.) understanding how meaning itself works such that every sign houses multiple meanings which may be deployed simultaneously. Is a "wink of any eye," Geertz famously asks, a man merely "rapidly contracting his right eyelid" or is he "practicing a burlesque of a friend faking a wink to deceive an innocent into thinking conspiracy is in motion"? "Thick description" defines the researcher's recognition that the strength of their analysis ultimately rests upon their ability to decode the multiple, changing and fluid meanings in this layered context.

3 EMERGING THEMES: GENDER PLAY, INTERNATIONAL PLAY, & TEAM PLAY

3.1. Gender as Obstacle or Code in Engineering Education?

Most feminist studies of science and engineering show that it is not women or their gender but the broader cultural and engineering educational and work climate with its assumptions about gender that hinders women's interest, persistence, progress, or success. To understand this climate, gender norms as they interface with especially women's learning, have been studied. But women's studies also teaches us that while pre-established meanings and associations are attached to gender – as well as to the scientist and engineer as male – by virtue of being constructed, they are also changeable.

Within this context of the complex nexus of work/play relationships that emerged from interactions among students in the lab, we observed a main pattern of behavior focused on gender – though we also noticed secondary patterns of what we will call "international play" and "team play." By the "theme" of gender in the lab, we mean that in almost every example of interactions, definitions and roles prescribing masculinity and femininity appeared to influence student inter-relations – the level of authority a student occupied or was given, the amount of praise a student received, or how a student even behaved. Women, under certain conditions, would take roles of authority, initiative, control over data, and coordination, especially of final products (lab reports) in lab-groups – even while men typically controlled the use of equipment and conducted experiments.

In this study, 3 lab sections met on alternate weeks for 2 to 3 hours, each with between 10-20 juniors and senior students in each lab. On average, these labs consisted of 32 percent female students, with the range between 9 percent—50 percent per/lab group. The students were predominantly "white American" and in their early twenties, though in some cases, diversity of ethnic/national background was equally or more prevalent than gender diversity. In this case, less than 10percent of the students were "international" and/or "older" students (in their upper 20s, 30s, and 40s). Two "international" teaching assistants (TA) were responsible for facilitating the labs.

We also noticed the theme of "international play," where students would often take on certain roles – whether dismissive, joking, taking advantage or avoidance – with respect to international TA's. And finally, we noticed "team play" – how predetermined identity issues would both get "played out" and "worked out" and changed through the common task of completing an experiment.

In analyzing these emerging themes in the geotechnical lab, readers may be mindful of several points of interest for engineering educators: (a.) the importance of collecting concrete data and examples of women and minorities' experiences in engineering that may contribute to their under-representation; (b.) analyzing an institution/college's climate from women and diverse students' perspective for purposes of awareness, comparisons with other institutions, administrative support, and improvement; (b.) promoting simple, pedagogical changes in semi-autonomous spaces, like the laboratory, including skills that women and diverse students are already using to cope with their minority status; (c.) encourage teacher-talk on simple practices to promote equity in the classroom so that all students can expand their education, skill-sets, (e.g., communication) and career prospects. Qualitative analysis of the geotechnical lab also opens up questions about how to use other classroom and non-classroom sites to promote a "total impact" for women and diverse students coming through the educational pipeline.

3.2. Background & Setting

Undergraduate soil mechanics is a required four-credit course in the Department of Civil and Environmental Engineering. Its main goals are to understand and apply the fundamentals of soil mechanics to real-world engineering problems and to demonstrate teamwork skills through group lab assignments, including the ability to produce clear and concise technical reports. During junior or senior year, students take the course, which consists of two 80-minute lectures per week and six three-hour labs during alternate weeks over the semester. While discussion is permitted in lecture, robust interaction, discussion, and questions are promoted in the hands-on "problem-solving" approach of the laboratory.

Students register for one of three lab groups, each with ten to twenty students. Labs are taught by two graduate teaching assistants (TA's) and one undergraduate student – all mentored by the faculty member. The TA's typically major in geotechnical engineering and are responsible for prepping equipment and materials, reviewing theory, providing guidance for conducting experiments, grading lab reports and weekly assignments, and for holding office hours. During lab, TA's provide a structured lecture and then form teams to complete the experiment: their only guidance is that teams must be limited to four or five students which generally do not change over the semester. Students, in short, take up the lion's share of responsibility for setting up their experience and working environment, completing the lab, and preparing/submitting team lab reports.

The second author, a TA and facilitator with undergraduate soil mechanics courses at Syracuse, used her experience with teaching both large and small labs to maximize the "less structured" environment of the lab in observations. She remained in the background, sat in a chair at the back of the room, and on occasion, when she walked by groups and their equipment for a better vantage point, she would only respond to questions directed to her by students. She explained her study, but did not initiate dialogue, or deliberately influence student behavior or distract them from their work. Each observation lasted between 1.5 – 2 hours. Care was taken with field notes to accurately reconstruct observations, interviews, and occasionally student notes – they were then coded according to our three main themes (gender play, international play, and team play), which were then further subdivided into subcategories for analysis. Two final, unstructured interviews were also conducted: one with a female undergraduate student and one with a teaching assistant, lasting approximately 30 minutes.

3.2.1. "Gender Play"

By "gender play" in the lab, we mean that in almost every observed interaction, gender appeared to influence the role a student played, the level of authority taken or given, the amount of praise received, even how a student behaved.

Feminine/Masculine Behavior

In many instances, "stereotypical" feminine/masculine behavior was observed, along with typical sexual politics. In the beginning of labs, male students would often cluster together and talk and joke with one another. Even during labs, joking, teasing, and competing were major components. For example, when one male student asked another if he had performed the task, the male student said, "Yes, Mom." The male students also interjected playful comments during the labs, such as "Cheese, it's just like slicing cheese," or "Plfff," in response to removing a sample from a cylinder.

Female students would often sit or stand to the side of the main groups. For example, when the lab was held in a separate lab room, several students arrived late. Male students pushed through to see equipment, whereas, female students stood in the hallway. When female students were together, they talked quietly or commented in response to male comments, such as "That's disgusting." One female student stood up in the middle of a lecture, made a motion her bottom was sore, and mouthed, "Owww."

Female students also seemed to show concern for other students – especially the male students. For example, one female student asked a male student if his hands were tired from mixing; she offered to mix. Female students also seemed to notice the "soil" more. For example, one female student held her shirt up in front of her nose to shield the dust. Several female students brushed soil from their backpacks or chairs.

The male and female students also spoke to each other in stereotypically gendered ways. For example, one female student said, “Hi, honey” to a male student. There were also instances of mutual attraction. For example, one male and female student occasionally held hands and whispered into each other’s ears. On another occasion, a male student went over to another group and attempted to steal the calculator from one of the female students in a flirtatious manner. One female student untied her hair and started looking at knots while a male student started massaging her hair in an exaggerated manner.

Roles

During the first observation, there was only one female student in the lab, and she belonged to a “mixed” group – it contained one female student, one international student, one older student, and one typical “white American” in his early 20s. While the issue of “roles” did not immediately present itself, we noticed that in general all members actively participated in the lab with the exception of the “typical” male student.

During the second observation, however, there were four “mixed gender” groups: although there was one female student who actively participated in all phases of the lab, including preparing samples and performing tests, the majority of female students chose to perform “support” roles – such as taking notes, weighing samples, and coordinating activities. Similar observations were observed in later labs.

By contrast, the male students generally prepared samples and performed tests. In one “mixed gender” group, a female student was holding a stopwatch getting ready to time a test when a male student walked up to her, took the stopwatch, and used it for the test. The female student simply returned to taking notes – a job that few male students performed. This was even more apparent when the lab moved to another room, and the majority of the male students did not even bring paper.

Similar gender role dynamics were noted in both interviews. One female student interviewed stated:

For the most part, girls blend in, or try to. We have three lab groups. Two girls are in my group. The guys generally do the lab part, like drop weights. Girls are the record keepers. The other girl in my group took notes during the first few labs; I’m doing them now.

She also stated that, “In the beginning, three to four of the five members of our group took notes. One boy never took notes. Now, me and the other girl are the only ones who take notes.” It is interesting that “note taking” was a shared activity in the beginning, yet with time evolved into a “female” role.

Another similar comment about gendered division of labor came up when this female student was interviewed about who writes lab reports. She stated:

We split it up, but I do the coordinating and put everything together. I would rather do the lab myself…I don’t trust my group members to finish the report. They are pretty good, but I coordinate everything, make sure the report is done right, and hand it in…They are happy.

Even the TA’s interviewed made similar comments and thus shared similar views about gender roles in the lab. For example:

The female students are very careful. Take data. Do calculations. The male students have more skill when doing the test. They are better with equipment. It seems most female students take data. Males will do the test.

Authority

In general, male students dominated the lab. Female students had a tendency to stand back and allow male students to perform the tests. In one case, a female student asked the TA what the next step was, put down her notes, and then started the next step. But as soon as a male student came over, she returned to her notes. We are starting to notice a similar gender role dynamic evident in the “stopwatch” observation above: namely, women, when unimpeded by men perform experiments and its multiple tasks. But as soon as men intervene and assert their naturalized gender role, women desist.

It seemed that more female than male students had read the lab handout before lab. As a result, in many groups, male students often looked to female students for direction on what step was next, or what data needed to be collected. In one group, the female student stated each step to the group as the lab progressed. The female student interviewed noted that, “The guys keep asking me, ‘Are we done?’ ‘Do we have everything?' I feel like their mother." Female students also seemed to have authority over data-collection activities. For example, one female student said, "We'll start a whole new disk for lab 5."

On several occasions, male students were observed answering female students' questions. For example, during a lab lecture, a female student asked the TA, "is this an A?" – but a male student from her table answered her question. A couple of minutes later, the same male student asked the TA a similar question and the TA answered. On another occasion, a female student asked the TA if he had any sleeves for the compact disk that he just handed out. From across the room, a male student hollered, "You don't need one, just put it in your folder." Even in cases where the TA answered female students' questions, male students often followed with an explanation. For example, a female student asked one of the TA's a question, received an answer, but a male student in her group continued with hand motions, "The plane is here on this, like on a slope."

Male students also made several condescending comments to female students. For example, one female student asked a question and a male students said, "What are you talking about? Where are you?" On another occasion, one male students hollered, "Hey…Help us out here…How long do we time?," to a female student standing across the room.

Praise

On several occasions, female students praised male students. For example, during one lab a female student looked over to her group and said, "Good job guys…That looks nice guys, good job." I also observed many other "good jobs" and one "Go Jim!"

But I only observed one male complement, and it wasn't really a complement, "You were right." Even when female students did the majority of the work, no complements were given.

3.2.2. "International Play"

If we qualitatively defined these first sets of interactions in terms of forms of "gender" behavior, interactions, and roles, our second author also witnessed "international play" – cases where students would often take on certain roles, whether dismissive, joking, taking advantage or avoidance, with respect to international TA's.

Taking Advantage

During observations, students appeared to be "taking advantage" of the international TA's on several occasions through sarcasm/making fun, tardiness, and inattention.

Sarcasm/Making Fun:

Several students were often sarcastic and defensive with TA's. For example, when the TA did not completely answer a male student's question, the male student, "You didn't answer my question. Do we need to add all the data?" This same male student later questioned the TA, "grams of water, not milliliters of water?" when the answer was obvious. Other male students simply hollered questions from across the room. For example, "Yo, I can't see, can you stand on the other side?"

"Making fun" behavior consisted of grins and smiles that resulted from mispronounced words and "inside" jokes. The female student I interviewed made similar observations. She stated that, "The boys in our group make fun of (the TA). They don't think they're being rude. (The TA) is just a force to be dealt with." Distinct differences in language use were also observed as the semester progressed. For example, by the last lab, male students did not have any regard for the offensive language they used in the lab – a behavior not observed from female students.

Tardiness:

Tardiness was a recurring problem in the lab with the majority of students present on time during only two of the six observations. Students arrived anywhere from a few minutes late to more than one hour late and would trickle in throughout the lab. The TA did not negatively react to any of the tardy students. For example, on one occasion the TA said, "If any questions, or came late, just ask me."

During the interview with the TA, I asked him what he thought about late students. He said, "Not good. From my logic, wait 5 minutes. Will start. Unfair to others. Wrote in lab handout, 'Please come on time.' Won't give make-ups."

Inattentive:

Many students were inattentive during lectures and demonstrations. For example, some students would chatter, not pay attention, continue with their work during demonstrations, take care of personal needs during lectures (hanging backpacks, changing the thermostat), and talk about anything but the lab while working.

Avoidance

Many students tried avoiding TA's. For example, one male student walked around the tables, walked by both international TA's, and asked the observer for gloves. Many students also asked the observer questions. One student asked the observer, "Can I ask you sometimes. I have trouble understanding."

3.2.3. "Team Play"

The third theme that emerged from observations was how the students worked together in "teams." Because of the nature of work groups, which included "male groups," "mixed gender groups," and "mixed gender, age, and nationality" groups, some of the observations overlap with those used in other theme areas.

Male Groups

In general, there were three different types of male groups: the alpha male group; the collaborative achievers; and the jokers. In the first group type, the so-called "alpha male group," one male student took charge. This male student would move quickly around the lab and not waste any time. At any given time, between two and three of the other group members would help. These groups generally finished the lab quickly. The second group type exhibited male students working together. They would all weigh the samples, mix the soils, and take turns performing different elements of tests. These groups also finished ahead of the other groups. The third group type is referred to as the "jokers." These male students continuously joked, teased, told stories, and competed with one another – challenging each other or betting beers as to if they were doing the test right. One male group called another male group "Cry babies." In these groups, generally two to three members actively participated and one to two students performed supportive roles, such as taking notes and weighing samples.

Mixed Gender Groups

In mixed-gender groups, students more often than not acted according to "gender-specific" roles and behavior. For example, female students were generally "note takers" while male students were "doers." However, in one group that had two female students, one female student took the lead, prepared the samples, and did experiments, while the other female student played a "gender-specific" support role. Another observation was interesting. In another group, when only the female student was present, the female student started the lab by herself and remained an active participant throughout the lab – even once the male students arrived.

Mixed Gender, Age, And Nationality Groups

In these groups, students generally worked well together. Female students did not play traditional gender-specific roles. For example, male students took notes and female students actively participated in the lab. It was also observed that younger students looked to older students for direction. The example used earlier when the older female student interviewed stated, "I feel like their mother," supports this point. Overall, the groups that had a mixture of students (male/female/older/international students) seemed to work best together: there was more equal participation in conducting experiments and in discussions of dividing up work and final grades.

3.3. Gendered Roles & Behavior: Analysis

To return to Thorne's evocative notion of "play," our central claim turns on the realization that students were not only engaging in work or work-related interactions in the geotechnical lab. Instead, in the process of completing assignments, they "played" across multiple levels – with relationships to other students, peers, and authority figures (facilitators), with patterns of behavior organized by gender, nationality, experience, and learning style, with group construction, and with personal identity. We name some gendered patterns of behavior that we noticed by focusing on some of the gender roles that women undergraduate engineering majors and minors took on in interactions especially with men in the engineering lab:

(1.) *Stereotypical Gender Roles:*

Women in the lab would often easily and without hesitation occupy a gendered role – submissive, non-participatory, inactive – as would men. But we did notice both disruptions of these roles at the beginning of class and at the end of class amongst different members. These roles also included behaving more or less feminine in the lab context.

(a.) Excessive femininity: women would exaggerate their femininity – pretending to not understand a piece of equipment or volunteering to nurture male colleagues

(b.) Excessive masculinity: men would often aggressively or rudely take charge of experiments and relate to other women as if they did not know how

(2.) Female "Supporting" Role:

Women offered time and energy to support or aid male colleagues as group-leaders by note taking and verbal support – instead of taking the initiative to lead an experiment. Taking a supportive role also included deferring the credit to male colleagues or down playing women's own talents and interests in the lab.

(a.) Credit deferring: once an experiment was successfully achieved, women would often credit male partners who had not worked as hard or emphasize the total group/team effort – instead of naming their own proactive role

(b.) Downplaying talents: certain women were far more competent and careful in performing experiments, but they would often hide or de-emphasize their competency

(3.) Personal vs. Professional Role:

Women in the lab context would often emphasize their domestic or personal attributes – instead of their practical, math, or analytical competency. Emphasizing the personal over work and studies also included co-opting their own leadership capabilities.

(a.) Co-opting leadership: when women did take on leadership roles, they would often devalue their skills or allow their role as leaders to become "gendered" and hence dismissed as mothering

4 CONCLUSION: LEARNING CONTEXTS IN IMPROVING SUCCESS

The findings of our study, while valid and illustrative in a number of ways, offer no general or fixed conclusions. Nor do we intend to make claims about consistency in outcome. The aim is to capture behaviors, discourses, and interactions that underscore gender dynamics in engineering learning contexts and communities. Indeed, these observations – when placed in the larger institutional context of programs for women in science and engineering (WISE, SWE) and their role in college/university culture more generally – offer perspective on the need for and the obstacles to change in the engineering classroom.

We also compared the results of this study to the informal observations of our third author, a senior female scholar with over 22 years of engineering teaching experience and women's advocacy – including teaching the undergraduate soil mechanics course at Syracuse for fifteen years. While observations always implicate the researcher and while they can never be absolute, but rather reveal exceptions, her experience with large and small classrooms, labs, undergraduate and graduate students revealed similar patterns of gendered behavior. For instance, our third author has repeatedly noticed a gendered "inner" and "outer" zone of student engagement with and focus around equipment in the laboratory and classroom – women tend to be placed in the outer zone whereas men occupy the inner zone closest to the equipment. Likewise, she was often surprised how well women would perform in lab report writing – taking ardent care and showing in their analysis that they had fully understood all aspects of the experiment – but despite doing the majority of that work, they would leave the lab feeling that they had not fully participated.

We want to offer two last caveats to that claim, however, drawing upon the experiences (documented in recent unstructured interviews) with senior engineering educators. First, our third author has noticed what we would describe as "gender play" at three levels. (1.) Female students abided by gender norms and cultural assumptions in the classroom, but they did not let gender norms get in the way of their activity and performance in the engineering classroom. In short, they did not let gender behavior slip into disenabling "gender roles." (2.) Female students would use the space of the engineering classroom to dispense with and/or depart from both gender norms and gender roles – when necessary. This seemed to be especially true of upper-level female students who had used several layers of resources – student groups, mentor relations, professional societies, service learning – to excel in engineering. (3.) Successful female engineering majors, especially juniors and seniors, began explicitly to discuss, show awareness of, and talk about redefining in positive terms what it means to be a female engineer – especially when given the opportunity and in peer mentoring younger students.

Second, this senior scholar and educator had much anecdotal evidence to mark the implications for often diverse women student's success in small, but profound changes in pedagogy, structured and consistent mentorship relations, in awareness of gender dynamics and roles in engineering through discussion, and in variety of types of classroom/group experiences. Cultural gender norms and their underlying ideologies, including the interactive practices they promote, can be addressed pedagogically to alter and enrich all student experiences in the engineering curriculum. Thinking about her own learning context, she recalls being in "those shoes" of being talented – but a gender and ethnic minority in a classroom of men. But a helpful and strong mentor was "sensitive to these things." In her case, "fortunately," she added, "my advisor from the beginning gave me responsibilities teaching, giving presentations, teaching his big classes – he knew I could do it." If "at times I grew disheartened, I would use my class performance to make it clear that I knew what I was talking about…."

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