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Perceptions of the Design Process: An Examination of Gendered Aspects of New Product Development*

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A study to examine students' perceptions of the design process was conducted in the freshman/sophomore class E39D: Designing Technology for Girls and Women at the University of California at Berkeley. The course covered gender issues associated with new product development from a human-centered design perspective. Students worked in multidisciplinary design teams and participated in interactive workshops with target users and industry sponsors. The class was taught as part of Berkeley's Virtual Development Center sponsored by the Institute of Women and Technology (www.iwt.org) and supporting companies in the San Francisco Bay area. Three forms of data collection techniques were used: interviews, questionnaires and a design process assignment. Evaluation showed that students developed a strong belief that 'good design' dictates that technology can and should serve all members of the potential user population, including those traditionally under-represented in technology. Finally, students showed an increased level of confidence in technology and an increased comfort level working on design projects.

INTRODUCTION

THE TECHNOLOGICAL advances made over the past few decades have not impacted all populations equally, begging the question: how can a wider range of people benefit from current technologies? The specific question motivating this paper is: how can more women have an impact on the design and deployment of new technologies?

The purpose of this paper is to address this question with respect to the UC Berkeley undergraduate course 'Engineering39D: Designing Technology for Girls and Women'. This course took place during the spring semester of 2003 at the University of California at Berkeley, and was taught by Professor Alice M. Agogino (Mechanical Engineering) and Professor Jennifer Mankoff (Electrical Engineering and Computer Sciences). In this paper, we evaluate to what extent this course resulted in the students feeling that technology could serve women and that women could influence the design of new technologies.

Our evaluation addresses three key areas: how technology is designed with respect to women, the degree to which technology serves women, and who among today's female youth will work in technology in the future. We address these issues by asking whether the class met the following goals:

- Did this class result in the students believing that designing technology for traditionally under-represented populations, such as women, is 'good design'?
- Did this class result in the students believing that technology can and should serve a broad and diverse population?
- Did this class result in women in the class being more inclined to work with technology and/or in a technical field.

We will argue that this class met the goals described by the first two questions and some aspects of the third. Interestingly, counterintuitive results were achieved from the third question when comparing the target class with the results of a required freshman engineering design class. We also suggest improvements to the course that could result in more clear and positive results with respect to the third goal.

COURSE BACKGROUND

This course sought to cover gender issues associated with new product development (e.g. readings [1–7]) from a human-centered and contextual design perspective [8–9]. Students learned to apply state-of-the-art information technology, teamwork [10] and current design processes in new product development [11] to tackle solutions to crucial societal problems, with a focus on those problems that affect girls and women. This course was co-listed in the College of Engineering and in the Department of Women's Studies, and covered design issues from both engineering and social science perspectives.

This course was comprised of 12 students (10 women and two men), all either freshmen or sophomores. Of the 12 students, half were declared

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in a technical major—computer science, applied math or architecture. Two of these students were computer science majors from Mills College, a women's college with an articulation agreement with UC Berkeley. None, however, were engineering majors. The others were in the humanities or social sciences with majors in a range of disciplines including business, economics, psychology and political science. The students met once a week throughout the semester to cover topics related to the design process. The students were expected to meet outside of class with their team members to prepare the required project deliverables.

The problems and the populations the students chose to serve were determined by the students through service work conducted prior to or during the first two weeks of class. Two of the teams elected to work with local museums to design exhibits appropriate for both girls and boys. A third team chose to work with a local girls group called 'Girls, Inc.' to develop a workshop that taught girls how to make movies about their lives. The students had the opportunity to work in multidisciplinary design teams, give both individual and team oral presentations, and attend an interactive concept generation workshop involving target users and industry sponsors. This class worked closely with the Anita Borg Institute for Women and Technology (www.iwt.org) and supporting companies in the San Francisco Bay area. The mission of IWT is to increase the impact of women on all aspects of technology and to increase the positive impact of technology on the lives of the world's women. The students had an opportunity to present their conceptual designs to other student groups at the IWT conference in April 2003 (see Smith College, TOYtech, for course similarities [12]).

RESEARCH METHODS

The three core data collection methods were questionnaires, interviews and a design process assignment. The questionnaires consisted of multiple-choice questions which were intended to gauge if the students were interested in working in technology and/or in serving their community. These questionnaires were distributed both at the beginning and the end of the semester, and the results compared. Additionally, the student co-authors of this paper conducted one-on-one interviews. Students were asked in these interviews to explain their feelings about the course, their comfort level with technology, what types of technology they currently use, and whether or not they could see themselves working in technology in the future. The objective of the interviews and questionnaires was to determine changes in the levels of motivation and confidence associated with the students' use of and interest in technology as a result of this course. For the design process assignment, the students were asked to depict their concept of how the design process worked, both with and without taking gender into account. The students were asked to do this assignment both at the beginning and end of the course. The design assignment was used as an effort to capture each student's view of the design process before extensive exposure to design and then assess how that view changed as a result of the course.

The following sections define our evaluation of the course impact with respect to the three research questions posed earlier. To support our claims we will cite data gathered using the methods outlined above.

PERCEPTIONS OF GENDER IN THE DESIGN PROCESS

By the end of the course, the students of E39D appreciated that good design involves evaluating the needs of all possible customers. Specifically, technology used by women must be designed with women in mind. This does not mean that it must be designed exclusively for women, but rather that 'good design' dictates that all genders, cultures, religions, disabilities, socioeconomic standings, etc., pertaining to possible customers can and should be considered throughout the design process. For the purpose of this paper, we will define 'good design' as design that best meets the needs of all possible customers, including those customers not traditionally considered in the design process. This definition is in accordance with the observations from the Mudd Design Workshop III, which concluded that 'good design' requires diversity [13].

The class taught that, in order for women to be able to use technology optimally, women must be explicitly considered in the design process. Emphasizing customer-centered design, the students were required to meet with potential customers in order to gauge how technology could best serve them. As a result, they learned how to include their customers in their design process. According to one student:

> 'The class has altered my perception of how technology should be designed . . . I think that it is important to include people who would be using the technology as part of the designing process, whether that is by directly including them in the design team or having the target groups test out the technology as it is being created to give feedback, for that's the best way to ensure that the technology will be used once it is completely developed.'

In spite of the course focus on including girls and women throughout the design process, students felt that this must be done without the exclusion of boys and men. We found through our interviews and surveys that, when it came to their own personal experience with technology, many of the female students did not like being singled out as unique simply for being a woman in technology. Although they wanted their opinions to be considered, they did not want this to happen at the expense of the men. When asked how they felt about working in a technological capacity often as the minority, many girls expressed a similar sentiment: they wanted their opinions to count, but they did not blame individual men for being in the majority. More importantly, they felt that a more equitable environment could be achieved. The students expressed this belief through the projects that they chose. Two of the three groups chose to work on projects that involved both girls and boys as their target customers. While designing these projects, the students made a concerted effort to design something that worked well for both girls and boys.

Students showed an understanding that 'good design' went beyond the consideration of just men and women; they felt all minority populations should be included. A poignant example comes from a student in the class who uses a wheelchair. The students were able to see first-hand how problematic design can be when it does not consider the disabled. When this disabled student and her group tried to use an elevator in a public transit station, they found that she barely fit into the elevator. She noted that, if she were not able to use her hands, she would not have been able to press the buttons to operate the elevator and, because of the elevator's size, her attendant would not have been able to ride with her. She also commented that the elevator was located in a dark and distant location of the station out of sight of the station's attendant. She extended this example to a parent with a child in a stroller, who would have difficulty fitting into the elevator, or a person with a number of parcels, who in a dark and obscured location would be susceptible to attack. The students who shared this experience observed that, if they were to design a product that focused exclusively on women, or simply on men and women, without considering other populations, their products would clearly be limiting the number of potential customers. This experience underscored the point that to ignore any one group of people in the design process could make a technology unnecessarily less useful for others.

Another example comes from an interview in which one student drew an analogy between his educational experience and that of designing technology for diverse users. The negative effects of excluding a minority population in the design process may be revealed in the fiscal failure of a commercial product, but negative effects can also be revealed in instructional design with reduced quality of the classroom experience. The student in question compared his general architectural courses to others that were more balanced with respect to gender. He felt that the more balanced classes were livelier and more open to diverse perspectives, whereas he felt that the quality of his architectural classes was compromised by the lack of diversity. He compared this example to the design process: when one group is excluded or absent, the lack of diversity can result in compromised quality.

Finally, the students felt that, by including all possible customers in the design process, there could be unexpected yet desirable effects, giving them additional incentive to include all possible customers in the design process. The students studied a case where one school was remodeled to better accommodate the disabled, resulting in a campus that was easier for everyone to use. According to one of the students in her interview:

> 'After seeing the different types of design that one can come up (with) based on what the target audience is, I realized that it should all be about 'good design'. For example, when that high school decided to remodel the school so that handicapped people could get around easier, it made the whole facility easier to use for everyone—even people who weren't handicapped.'

Overall, the students felt that women must be included when technology is designed, and this should not have to happen by excluding others. The students learned to address the question: how can the needs of minority populations be addressed without pitting those populations against the needs of the mysterious and inarguable whole? The students were able to see by way of this class that addressing the needs of women and other minority populations does not inhibit the design process but can in fact result in better design.

PERCEPTIONS OF WHO TECHNOLOGY SERVES

This class resulted in the students believing that technology can and should serve a range of customer populations. We found that, before taking this course, many students were not aware that technology was traditionally designed in a manner that excluded certain members of the population. Through the material covered in the course and the semester group project, the students came to understand that technology can and should serve everyone. During the first two weeks, the class studied examples of designs that did and did not consider a broad population in the design process (e.g. automotive design, air bags, information technology, classroom environments, toys and video games). The students were surprised to find that technology could be made to better serve all members of the target populations. This lack of awareness was likely due to the fact that students were used to seeing and accepting technology in a singular way, that being the way that technology is traditionally used and designed. Clewell and Campell refer to extensive research in which girls perceive math and science as the 'domain of White boys, that they do not see these subjects as useful to either themselves or humanity in general' [14]. For example, one student stated in her interview, 'We often think that technology is only meant to be used by professionals.' To draw a parallel between this issue and the former belief that computers would never need to extend to a personal computing market, people have an inclination to believe that technology can only be used in the ways in which they already see living examples. This lack of awareness was probably also because students may not realize that different people use technology in different ways. According to one student, 'I never knew there was such a difference in technology for men and women.' Because people of all different types have always been made to use technology that is designed for one specific type of person, many students were not even aware that there was an alternative. Thus, before taking this course, a number of students were unaware that technology could be designed in a manner to better serve all members of the population.

This class provided students with several examples of technology that served varying sectors of the population, sectors that are traditionally under-represented in the design process. For example, students were exposed in two different lectures to the design of video games for girls. In one lecture, Yasmin B. Kafai of UCLA gave a lecture on research she had done that involved girls designing video games [1]. Students also read Justine Cassell's paper 'Genderizing HCI,' which discusses various issues concerning designing information technology for women [2]. Additionally, students were taught different design paradigms that allowed for the inclusion of all types of people and of different types of needs throughout the design process. First was 'Universal Design', defined as 'the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.' Students also studied 'Empathetic Design' [9], which stresses looking for 'needs that customers may not yet recognize.' While the first design paradigm helped students learn how to include traditionally neglected populations in their design process, the second paradigm helped students learn how to include traditionally neglected needs in their design process. Thus, the various topics of the class worked to make students more aware of the fact that it is possible to design technology in a manner that better serves the various sectors of the population.

The group teamwork gave students personal experience designing technology that serves girls and women. There were three project teams; while one team focused specifically on girls as their target customers, the other two created projects designed for children of both genders. The team that targeted girls created a workshop that taught girls how to make their own short films, intentionally using current technological media. Another team sought to create a science and technology museum exhibit, entitled 'the world in the palm of your hand', which sought to bridge the cultures of the world with science and technology with the cultures of the world. The last team worked on a museum exhibit that explored the concept of 'fear' in terms of the physiological and sociological issues. This third team devised a series of activities along this theme, some of which were physical while others required sustained mental involvement. This displayed a comprehensive understanding on the part of the students that a variety of approaches must be taken in order to teach the principles to the young students. These last two teams concentrated on making exhibits that engaged both girls and boys equally. All three teams made projects that were targeted at children or teenagers, groups that many people may not typically associate with technology. By the end of the semester, students had first-hand experience of designing technology for girls and other traditionally under-represented sectors of the population.

We found that, as a result of the various topics and work the students were exposed to throughout the course, the students came to believe that technology can and should serve such populations. The students who were not aware that technology could serve all members of the population understood through course study and experience how it could do so. According to one such student in her interview: 'I have come to learn that good technology is something that is accessible to all, no matter the age, sex, background of the user and his/her level of expertise/experience with technology.' Another student in the class stated in her interview that, 'this class made the fact that technology can serve everyone from toddlers to anyone else concrete for me.' Thus, for those students who were already peripherally aware of the concept that technology can serve everyone, this class helped to solidify that idea for them. The only students whose minds were not changed on this issue were the ones who had already reached the conclusion that technology should serve everyone; according to one such student, when asked if this class had altered her perception of whom technology should serve, she said: 'No. I've always thought that technology should . . . be useful for everyone.' Even though the students had different perspectives about who technology serves at the start of the course, by the end of the course all students agreed that technology can and should serve all sectors of the population.

PERCEPTIONS OF WORKING IN A TECHNOLOGICAL FIELD

The students of E39D: Designing Technology for Girls and Women were given identical surveys at the beginning and end of the semester. For the purposes of comparison, a freshman engineering design course, FED, was given the same survey only once, at the end of the semester. Of these students, it is assumed that the students are majoring in engineering, because this is a required course

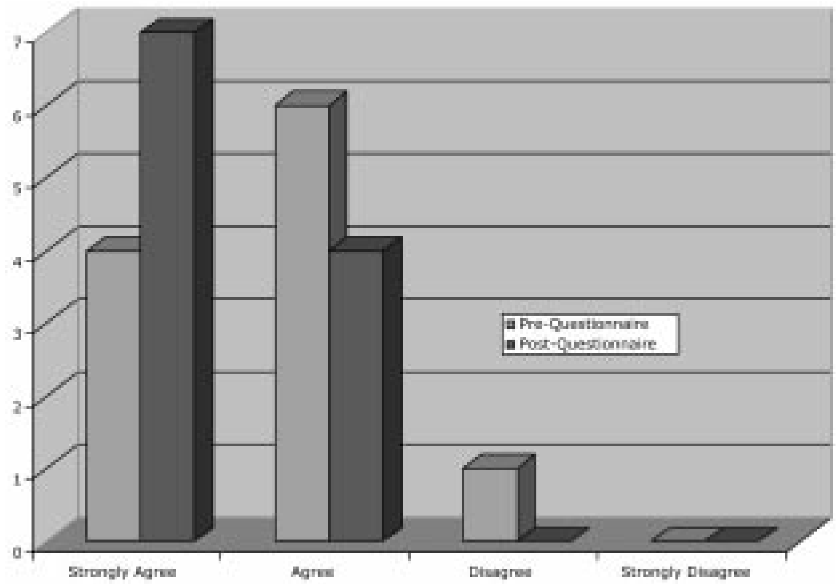

Fig. 1. Pre- and post-questionnaire responses for the question 'I am comfortable using technology' given to E39D students.

for engineers. Fifty-one FED students took the survey (19 females and 32 males); 11 of the 12 students from E39D took the survey at both the beginning and end of the course. Among other questions, all students were asked to respond to the following three statements:

1. I would consider a career in a technical field.
2. I am comfortable using technology.
3. I would be comfortable within a technical field.

(Available responses: 1—strongly disagree, 2—disagree, 3—agree, 4—stongly agree)

While all of the women surveyed in FED either 'agreed' or 'strongly agreed' with the statement 'I would consider a career in technology', only five of the nine female students surveyed from E39D said they 'agreed' or 'strongly agreed' in the post-survey. These differences understandably reflect the self-selection of FED students who are intending to major in engineering, in contrast to the students from humanities, social sciences and professional schools in E39D.

The pre- and post-questionnaire revealed an increase in confidence in using technology for the students in E39D, as shown in Fig. 1. Using a 4-point scale (with 4 being the highest at 'strongly agree'), the average score to the question I am comfortable using technology moved from 3.27 in the pre-questionnaire to 3.64 in the post-questionnaire, with the majority being in the 'strongly agree' category. This is a statistically significant difference, according to a paired-sample t-Test, $p < .05$.

We found the results of the questionnaire given to the engineering students in FED at the end of the semester to be quite surprising (see Fig. 2). Only three of the 19 (16%) female FED students 'strongly agreed' with the statement: 'I am comfortable using technology'. In contrast, of the 32 male FED students, 15 (47%) said they 'strongly agreed' with the statement. In fact, the E39D students

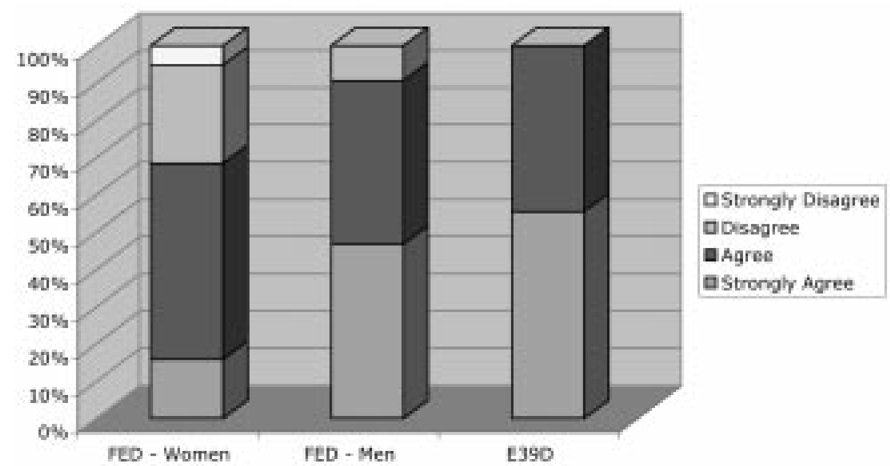

Fig. 2. Responses for the question 'I am comfortable using technology' given to E39D and FED students at the end of the semester.

from a range of disciplines rated their confidence in technology higher than the female engineering students in FED at the end of the semester (Fig. 2). E39D women moved from 3.27 (pre-test) to 3.64 (post-test) on this question and all E39D students reported that they were comfortable using technology (56% 'strongly agreed' and 44% 'agreed'). One possible hypothesis to explain this difference is that women, in general, could be made to feel more comfortable using technology if they were made aware of the many ways in which technology could serve them. Another explanation is that women are more likely to build confidence in using technology if given educational experiences in which women are in the majority.

Finally, both classes were asked to respond to the statement 'I would be comfortable within a career in a technical field'. The E39D students showed an increased trend in rating for this question between the pre- and post-questionnaire, although it was not statistically significant (Fig. 3). Again there was a large gender difference in the responses in the benchmark FED class. For this question, only four of the 19 (21%) female engineering students 'strongly agreed' with the statement. In stark contrast, 16 of the 32 (50%) male engineering students 'strongly agreed' with the statement. Surprisingly, the female E39D students from a range of disciplines gave the same average ratings (3.0) as the female engineering students in FED (3.05) at the end of the semester to this question. This is amazing, considering that there were not any engineering students in E39D. It is also of concern that so few of the female engineering students in FED were optimistic about their comfort level in working in a technical field.

Through individual interviews, it was concluded that a number of female E39D students became more inclined to work in a technological field, even if it were only as part of a design team. The evidence supporting this fact is based solely on personal statements, but to go beyond such statements more research would be necessary. For example, no one indicated that they were going to seek a job or internship in a technological field, and no one planned on changing their major to a technical one as a result of this course. We did find that, overall, student interest in technological design increased. For most of the students, this course was the first time they had been exposed to technological design and the design process. This exposure gave them greater insight into how technology and design affect people with respect to the everyday world. According to one student when interviewed:

> 'I enjoyed being introduced to the design process. Before this class I had no idea that the design process was such an extensive process. It really opened up my eyes to what would be expected of me in the future if I planned to pursue a career in designing our nation's future technology'.

This exposure seemed to spark an interest in technological design for the majority of the students. This is substantiated by the fact that most of the female students indicated in the course survey that they would, if given the chance, continue with their course project. As a side note, a number of these students also indicated that they did not feel as if they had the technical expertise necessary to move their project forward. Nevertheless, these numbers indicate that this course had a positive impact and in

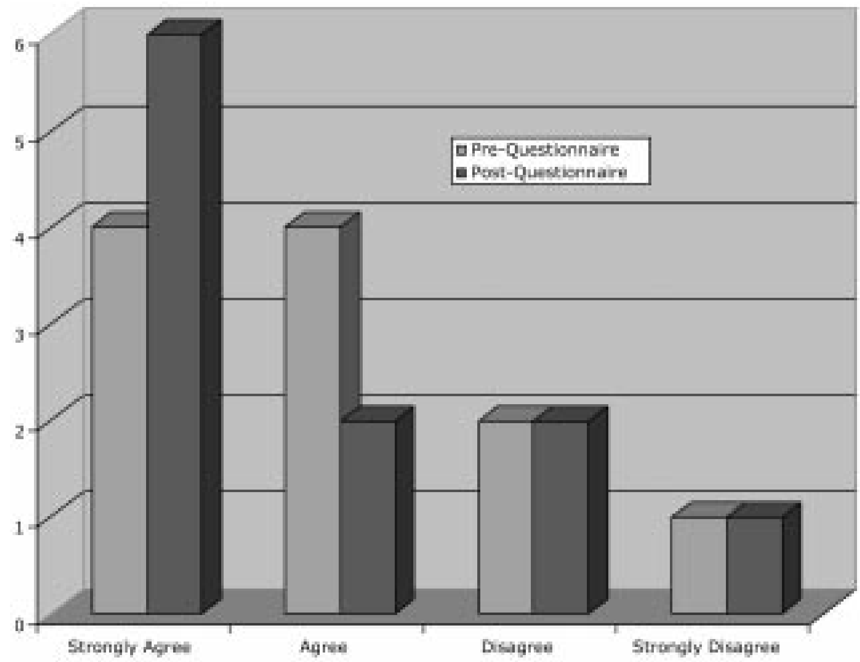

Fig. 3. Pre- and post-questionnaire responses for the question 'I would be comfortable within a career in a technical field' given to E39D students.

fact sparked an interest in design for the majority of students.

Further, when asked whether students would be interested in pursuing a career in technology, the majority of the female students we interviewed indicated that this was the case. All of the women fell into two categories: either they came into the class already knowing that they wanted to work in a discipline that was scientific or technical, or they came into the class not interested in working in such a discipline. We are happy to say that this course did not turn any of the women that knew that they wanted to work in a technological discipline off from doing so, and they are still planning on pursuing technical or mathematical careers. The other women showed varying degrees of interest in working in design for technological products. More than half of these students mentioned in their own words that this class had increased their interest in working in design because they now realized that design could require applications of sociology, anthropology and psychology. For example, one student said in her interview: 'I am more inclined to work in a technological field because I realized that the technological world requires a lot of input that is often non-technical in nature.' Another student discussed how she enjoyed discovering how technology could help members of the community that were in need of help.

COURSE IMPROVEMENTS

During final student course evaluations, essential improvements were repeatedly suggested. We believe that implementing these improvements would result in E39D having an even greater impact on the students, thus making them more interested in continuing an education and career in technological design. The improvements are as follows: (1) the number of course hours should be increased and (2) existing relationships between the local communities and the school should be pre-established before the start of the semester.

By increasing the number of units for the course, a number of obstacles incurred throughout the semester could be rectified. One problem associated with a seminar course (typically 1 or 2 units) is that the class expectation for a seminar course is different across the campus. As a result, the students in the course, who represented a broad cross-section of Berkeley students, came to the course with a diverse set of expectations. While some students believed that a seminar was for surveying a new subject, others believed it was for working on a small individual or group project. This course had hoped to accomplish a bit of both by exposing the students to the design process and allowing them to work with the community in small groups. This was a source of frustration for many of the students, who had not anticipated that the course would involve a great deal of team and project work. If this course were defined as a freshman technical elective, with an increase in units and a comprehensive course description, students may have a better idea of what to expect. Cross-listing, this course (Women's Studies and Engineering in this case) is still essential to creating a diverse class population. This is because those students who have chosen to study liberal arts should not be ruled out when designing technology; in fact they have proven throughout this course that they are capable to contributing in a variety of respects, including in a technological fashion. An additional benefit to increasing the number of units is that students could have scheduled hours for team meetings. The students found that, despite the necessity of team meetings for the progress of the student projects, it was difficult to find enough common time to meet with other team members.

> 'I would have liked to have some more one-on-one group time class time for this course. Perhaps, 30–40 minutes could be delegated as group time for each class meeting.'

With more course units, more time could be allotted for the course, of which time could be set aside for team meetings. This would ensure that all members could meet and everyone would be on the same page with respect to the project.

The feedback from the students regarding the service-learning component of the course suggested that the communities should be pre-selected or assigned at the beginning. Many students felt that the course and their work suffered because a lot of time was spent identifying the community organizations and establishing relationships with them. One student wrote:

> 'I think that community service programs for the students in this course should be assigned. This way students can spend more time getting to know their community and those community's needs as opposed to spending a good majority of their time looking for a community to provide a service to. This I believe will lend more time for structured product and design development of a product or project that will best help each individual group's assigned community.'

Another student commented,

> 'Choosing the community—Although I appreciated the fact that we got to choose our own community, I think we spent too much time in the first few weeks establishing a connection with the community that we could have spent developing ideas and such.'

One possible solution to this problem would be to have a number of communities with existing relationships with the school from which the students could choose. Because so much emphasis is placed on customer-driven design, it is essential for the students to have access to the customer. The delay that some teams experienced in identifying their teams and establishing communicative relationships with members of these communities hindered not only the progression and success of the students' projects, it failed to provide the students with an accurate impression of the fundamentals of customer-driven design.

CONCLUSION

We evaluated the effectiveness of Engineering 39D: Designing Technology for Girls and Women with respect to students' perceptions in three areas: (1) how technology is designed with respect to women, (2) the degree to which technology serves women, and (3) the extent to which this course can increase the number of women who are interested in working in technology in the future. We have found that, as a result of the lecture topics, readings and project work, the students in the course believe that good design practice should consider women and others who might use a product in the design process. The students also discovered from their personal experiences in doing project work and other class-related work that technology can and should serve women and any other underserved population to a much greater extent than it does today. We also found that the students in the course by and large indicated an interest in working in design in the future. Although none of the students were prepared to change majors from a non-technical to a technical field, the course increased their interest in working as a member of a technical design team. In order to better ensure that this course will have a lasting effect, we propose that the number of units students receive for this course should be increased and that the relationships between the communities with which the students work should be established prior to the start of the course.

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