Session XXXX

Diverse by Design: Increasing the Representation of People with Disabilities through Community Engagement

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Abstract

In this work, outcomes are presented from a pilot study course in biomedical engineering. A total of 16 undergraduate and graduate students in STEM-related fields were registered for the course on its first offering. The students were organized into small teams through a combination of self-identified interests, as well as randomized background and experience. The course included traditional lectures, structured online learning, hands-on design, and prototyping. In addition, guest lecturers spoke to the course on topics such as how to address disability matters, approaches to universal design, difficulties with existing public buildings and spaces, and limitations of currently available assistive devices. The student teams each coalesced around a "pain point" identified by members of the community. The teams iterated on design solutions, working with the "need-knower" from the community to test the designs. An Adaptive Design Challenge was held on the campus for members of the community to learn of the challenges faced by the community, test the existing prototypes, and provide feedback to the teams. At the conclusion of the course, satisfaction was gauged through a combination of measurements, such as written reflections, course evaluations, and progress made toward translating designs into the market. Overall, the positive outcomes experienced by the students, instructor, and community experts has indicated that the course should be offered annually, with a larger pool of potential students, and with more community engagement. It also indicates that efforts such as this could potentially be beneficial to recruiting and working with members of the population with disabilities.

Introduction

In the United States (U.S.), 1 in 5 individuals have a disability with 4 million people in the U.S. requiring a wheelchair.[1,2] Approximately 12.8% of Americans have a disability; 18% for working age.[3] There are multiple reasons, long-term and short-term, causing individuals to have decreased mobility and motor function. Individuals with chronic conditions often experience a diminished quality of life, due to functional decline and disability.[2] According to the National Center for Education Statistics, students with disabilities are an increasing subpopulation at postsecondary institutions.[4] In 2016, 19% of all enrolled undergraduate students reported having a disability.[4] Limitations in mobility present a substantial barrier to activities of daily living (ADL), which can lead to decreased access to education. As a result, the need for adaptive designs for individuals with different abilities is paramount. Changing the way we think before the design process can aid in the creation of a technology that can significantly improve an individual's level of independence.

One approach is the use of design thinking. Design thinking is a process used to help solve problems in a creative way.[5] This process has been shown to improve student's time management skills, create a positive experience among team/group work, and encourage the use of interdisciplinary communication. All of which help guide students to come up with creative approaches to best solve problems.

Design thinking follows a basic, sequential framework: define the problem, formulate an idea, prototype, and test. First, students talk with community members who have a distinct viewpoint on a given issue. This enables students to more accurately define the issue by better understanding a user's needs, problems, and insights. Second, students are encouraged to work with their peers to create ideas for innovative solutions. This step encourages creativity and provides the momentum necessary for the problem-solving process. Third, students begin to bring their ideas to fruition through prototyping. This step can be as simple as creating models with LEGO® or as advanced as developing a design through the use of a 3D printer. The main objective is to create tangible solutions. Finally, students are encouraged to test their prototypes developed from the previous step. This allows students to quickly determine the efficacy of their design. [5]

It is important to keep in mind that during this design thinking process some student groups quickly begin prototyping and testing, while other student groups spend more time thinking of what they want to create. It is not clear which approach is best, but nonetheless this framework has helped create better solutions to problems because it is designed to help students pivot and adapt when faced with the inevitable "roadblock" during problem solving. In this paper, we write about the implementation of a design thinking course in engineering, but strongly believe that this process and the skills learned in this course can be used across multiple academic areas.

Methods

A new course entitled "Adaptive Design for the Community" was created as an elective course in the Biomedical Engineering graduate program in a Southwestern public university. The course was cross-listed with several departments in STEM disciplines in order to recruit students with diverse educational and research backgrounds; for the same reason, the course was offered to senior undergraduate students.

A total of 16 students participated in the course during its first offering. The students were asked to complete a survey that included questions regarding demographic background, educational/research background, as well as experience with prototyping/crafting. They were presented with 5 potential design challenges that were previously identified by members of the community who have disabilities. Using these techniques, a total of 3 interdisciplinary teams were formed, each with a distinct design challenge.

Instruction was carried out through a combination of online learning following the IDEO design thinking curriculum, as well as traditional lecture, and interactive discussions. Student participation and learning was recorded in a central physical or electronic notebook, and assessed through a combination of quizzes, and project updates, and other means. Setting up milestones that the students had to meet along the way were used to encourage student groups to communicate with one another and ensure that they were making progress. The designs were tested by members of the public at a Challenge event, as well as by the need-knower of their team. Finally, students were required to create a video presentation of their final design as a way to both conclude the class project and promote creative ways of communicating their accomplishments during the semester.

Results

Although the use of electronic, anonymous course evaluations can be problematic, in this case, they proved to be very useful, as >70% of the class responded to the survey. **Figure 1** is a sample of anonymous responses to the question "What features of this course and of the instructor's teaching contributed most to your learning?"

- This class was much less a homework and test class and more of a group project and working together class. I loved the layout, it was very stress-free and helped me learn a lot more than I did for any other class.
- 1. Focus on writing down ideas into book 2. Hands-on projects 3. Working in groups throughout the class 4. Access to writing utensils and writing stuff in order to work in groups and think 5. Lots of brainstorming events
- The style of this course was very helpful for design thinking. Everything about this course was fantastic and will encourage anyone who has not taken this course to do so.
- Giving us real, tangible problems to solve.
- Using real life situations or people (their experiences).
- I really enjoyed the hands on activities and ability to delve right into developing prototypes after interviewing and understanding what our need-knower/user wanted. The use of wrong theory, persona challenges, and brain spins were creative ways to get us brainstorming and ready for our next activities. Having multiple class speakers was useful in understanding the different perspectives on user innovation or user design thinking in healthcare and on campus.

Figure 1. Sample responses to the question "What features of this course and of the instructor's teaching contributed most to your learning?" from the course instructor feedback.

From **Figure 1**, the enthusiasm for the course structure (e.g., "less homework and test class…") is clearly apparent. Of particular interest is the positive reaction to teamwork; while usually this is met with less excitement from engineering students, it is of critical importance for practicing engineers. In addition, the level of detail in the comments (particularly the final comment) is notable. The ability to recall interactions such as "Wrong Theory" and "Persona Challenges" (events included in 4 lecture periods out of the entire semester) is quite impressive.

Figure 2 is a sample of anonymous responses to the question "What specific suggestions do you have to improve the course and the instructor's teaching?" As previously mentioned, open-ended questions such as this one can make online, anonymous evaluations of questionable value, especially for female professors. However, as with the previous responses, the feedback to this question was very positive and quite detailed in analysis.

- Not sure, I loved it the way it was. I guess I just kept forgetting when I would have homework due.
- 1. More time to write in books 2. Access to printer to print out stuff for books
- I do not have any specific suggestions to improve this course. It was perfect!
- The course could focus more on teaching actual fabrication techniques for manufacturing usable products.
- Nothing really. I enjoyed the course.
- Include Physical Therapists, Athletic Trainers, other Engineers (Biomedical, Chemical/Biological, Civil, etc.), trade jobs (welders, someone from Fusemaker space, carpenters, etc.) for additional guest speakers. That way students can understand the whole aspect of developmental procedures. Extend the class time period to an hour and fifteen minutes or even two hours (maybe two days a week if you do this), that way you get more time to explore ideas and perspectives in class time. Have more events like the Adaptive Design Challenge to get information to larger groups of individuals on campus about the mishaps and challenges others face each day.

Figure 2. Sample responses to the question "What specific suggestions do you have to improve the course and the instructor's teaching?" from the course instructor feedback.

As with the previous set of responses, the overall reaction to the course (and instruction) was very positive. The final response is very detailed with specific ideas about specific types of guest lecturers to include to make the experience even more impactful. This level of analysis and reflection also seemed unusual in an online evaluation platform, which tend to be collections of concerns about grading or amount of homework, as well as requests for more practice problems. The suggestions made in this set of comments (and others, not pictured) are more reminiscent of the brainstorming activities within the class, in the spirit of continued improvement of the courses.

	White women	Asian women	Black women	Hispanic women	American Indian Women	Other	Foreign women
National Population (U.S.)	32.5	2.5	6.4	8.1	0.5	N/A	N/A
New Mexico Population	12.4	0.6	1.1	23	4.6	N/A	N/A
Natioanl Labor Force	31.9	5.7	4.3	4.5	0.2	N/A	A/A
National STEM Graduate Prgs	17.4	2.6	2.8	3.3	0.2	13.3	13.3
Southwest University	19.4	2.4	1.2	25.1	3.4	2.1	2.1
Graduate Program at Southwest University	14.9	4.3	0	19.1	0	12.8	12.8
BME class	25.0	6.3	0.0	25.0	6.3	0.0	6.3

Table 1. Course demographics (for women) compared to that of university and national demographics, as well as other STEM disciplines. In addition, 6.3% of the people in the class identified as female and disabled.

	White men	Asian men	Black men	Hispanic men	American Indian men	Other	Foreign men
National Population (U.S.)	31.4	2.3	5.9	8.3	0.5	0.9	N/A
New Mexico Population	13.1	0.8	0.9	23.3	7.5	7.5	N/A
Natioanl Labor Force	36.8	7.3	3.1	4	0.3	0.8	N/A
National STEM Graduate Prgs	20.9	3.2	2.1	3.1	0.2	2.9	25.5
Southwest University	16	1.8	1.2	17.2	2	3.1	3.1
Graduate Program at Southwest University	25.5	4.3	0	12.8	0	2.1	4.3
BME class	37.5	6.3	6.3	12.5	0.0	0.0	0.0

Table 2. Course demographics (for men) compared to that of university and national demographics, as well as other STEM disciplines. In addition, 6.3% of the people in the class identified as male and US veteran, and 12.5% identified as male and disabled.

Careful consideration of the demographics for the course show that the course has higher participation from members of minorities and groups that are traditionally underrepresented in the STEM fields. (See **Tables 1** and **2**). For example, 25% of the students from the class are Hispanic women, and 6.4% are Black women. In comparison, the national averages (as reported by the NSF) are 3.3% and 0.2% for the same populations. With the exception of Black women, these statistics are relatively similar to national averages (from the USA Census) and that of our State. A similar trend can be seen with regards to the male population; it can be noted that the class maintained a higher participation rate for both Black men and Asian men, 6.3% and 6.3%, when compared to the national average (as reported by the NSF) of 2.1% and 3.2% respectively. And with regards to Hispanic men in particular the class participation was at 12.5% in comparison to the national average of only 3.1%. Furthermore, the course had high representation from people with disabilities (12.6%) and from veterans (6.3%).

This data indicates that the pilot course drew from populations that are currently underrepresented in STEM fields, and which programs such as the National Institutes of Health and National Science Foundation make great efforts to promote the participation from. Guest lecturers and outside experts (need knowers) also included high representation from women, people with disabilities, and US veterans (66.6% were women, 44.4% were Hispanic, 22% were US veterans, and 11% identified as having a disability). These statistics should be considered preliminary, as they are from the pilot course, and statistically significant data will only be available after several years of the course being offered. However, it does indicate that the course's subject matter is of interest to people from underrepresented minorities and groups, which could therefore be used to recruit more members of these populations in the future.

Conclusions

The outcomes from the pilot study course in biomedical engineering are presented as such; from a total of 16 registered undergraduate and graduate students in STEM-related fields 3 small teams (4-6 members) were created based on a combination of self-identified interests, as well as diversity of background and experience (e.g., degree program; GPA; ethnic, racial, gender, and other under-represented groups in STEM; and experience with prototyping, crafting, and building). This course was a combination of traditional lectures, as structured online learning, as well as hands-on design prototyping. Guest lecturers with expertise in accessibility and design also spoke to the students on various topics: tactful addressing of disability matters, universal design approaches, the disadvantages of existing public buildings and spaces, currently available assistive devices as well as their drawbacks. Uniting student teams around a "pain point" personally identified by members of the community (e.g., lack of cupholders for wheelchair users), The teams were able to employ rapid prototyping to recapitulate on potential design solutions throughout the class. Working with the "need-knower" from the community gave the teams the ability to test each design.

An Adaptive Design Challenge was held on the campus for members of the community based on the challenges faced by the community in order to foster empathy as well as test the existing prototypes and provide feedback to the teams. The conclusion of the course was met with overall satisfaction from the students and was measured through a combination of objective measures, such as written reflections, course evaluations, and progress that the teams made toward translating their designs into the market. Overall, the positive outcomes experienced by the students, instructor, and community experts indicates that the course should be offered annually, with a larger pool of potential students, and with more community engagement. It also indicates that efforts such as this could potentially be beneficial to recruiting and working with members of the population with disabilities.

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