New Orleans JAZZED about Engineering Education

Paper ID #16789

Social Consciousness in Engineering Students: An Analysis of Freshmen Design Project Abstracts

Maya Rucks, Louisiana Tech University

Maya Rucks is an engineering education doctoral student at Louisiana Tech University. She received her bachelor's degree in mathematics from the University of Louisiana at Monroe. Her areas of interest include, minorities in engineering, K-12 engineering, and engineering curriculum development.

Dr. Marisa K. Orr, Louisiana Tech University

Dr. Orr is an Assistant Professor in Mechanical Engineering and Associate Director of the Integrated STEM Education Research Center (ISERC) at Louisiana Tech University. She completed her B.S., M.S., and Ph.D. in Mechanical Engineering, as well as a Certificate of Engineering and Science Education at Clemson University. Her research interests include student persistence and pathways in engineering, gender equity, diversity, and academic policy.

Dr. David E. Hall, Louisiana Tech University

David Hall is the James F. Naylor, Jr. Endowed Professor and the Director for Civil and Mechanical Engineering and Construction Engineering Technology at Louisiana Tech University. He received his B.S. from Louisiana Tech and his M.S. and Ph.D. from Georgia Tech. His research interests include trenchless technology and engineering education. He is the primary author of the Living with the Lab first-year engineering experience at Louisiana Tech (www.livingwiththelab.com).

Social consciousness in engineering students: An analysis of freshmen design project abstracts

Abstract

This research paper explores the motivations behind freshmen engineering projects, particularly as they vary by gender composition of the team. All freshmen in the engineering program at Louisiana Tech University must take and pass Engineering Problem Solving III, an engineering design class, before moving on to sophomore engineering classes. Students are instructed to team up in groups of two to five to design and construct a "smart product" using the knowledge gained from their previous Engineering Problem Solving I and II classes. At the end of the quarter, each team must submit a project abstract before presenting their work at the Freshmen Design Expo. This qualitative study looks at these abstracts in an attempt to find a pattern between the gender composition of the group and the motivation behind the product. Eighty-one project abstracts are analyzed, representing 227 students. Several distinct themes emerged from the analysis of the project abstracts. The most common themes were *Annoying and Frustrating, Efficiency and Time Saving, Safety, Elderly and Disabled, Health and Sanitation, Forgetfulness,* and *Children*. Analysis of how these themes map to gender composition of design teams is ongoing. These themes will help to understand how students view the impact that they can have as future engineers. Redesigning curricula and analyzing recruitment techniques to encompass particular themes may help to attract and retain more students in engineering. In this study, groups that had an equal number of males and females were more likely to design a socially conscious project than groups that were mostly male or mostly female.

Introduction

Freshmen engineering students at Louisiana Tech University take a series of three engineering problem solving courses as part of the Living with the Lab experience [1]. The third course culminates in an open-ended design project. Students spend about five weeks selecting, designing, and building a "smart" product. Throughout the first year, these students have implemented a variety of sensors and actuators using an Arduino microcontroller. Their smart product must sense something about its environment and respond or report based on this input. Students self-select their teams of two to five members (honors sections typically use teams of two). They are guided through brainstorming, production of multiple prototypes, and discussions with instructors and fellow classmates. Their final product is presented to a panel of judges at the Freshmen Design Expo. Before the Expo, student teams are required to submit a brief project description that is distributed to judges and guests. These descriptions are analyzed in this study to identify underlying motivations.

Students are not given strict guidelines on the intended consumer or intended use of the project so the students come up with a wide variety of ideas ranging from Lucky Charm sorters for picky eaters to clean water filtration systems for third world countries. The purpose of this study is to explore the relationship between the gender composition of each team and the motivation behind their project, in particular, the presence or absence of social consciousness.

Social consciousness

Social consciousness is an important part of life because it is what motivates us to perform services and supply goods to others. Social consciousness is paramount in engineering because it allows for various perspectives to universal issues. Social responsibility is the desire to do something to meet societal needs. Vanzdoort discusses the micro levels of social responsibility such as ethical codes for engineers and macro levels of social responsibility such as societal decisions about technology. He states that knowledge of the social aspects of engineering is necessary because of the environment in which engineers work [1]. Research also suggests that there is a need for global competence in the engineering profession. Lohmann, Rollins, and Hoey researched the importance of learning about cultures and issues worldwide [2]. Their study concluded that international study is key to becoming a successful global engineer. Though technical skills are necessary, they are not sufficient. To obtain ABET accreditation programs must ensure that students have the technical skills as well as the ability to demonstrate social responsibility. ABET requires that students in the program have "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" [3]. To effectively make an impact as an engineer, one must know where societal issues lie. Social consciousness has been a concern for engineering educators for some time now. One study showed that many engineers lack knowledge of social needs and trends [4]. Research has shown that social consciousness in engineering is especially important to female students because the ability to help society is a common reason that females choose engineering [5]. It has also been revealed that females are more likely than males to sacrifice salary in order to serve society [5], [6]. However, Matusovich found that more women than men felt that engineering values did not align with their sense of self. [7]. For this reason, engineering concentrations with more obvious societal benefit, such as environmental and biomedical engineering, attract more female students [8]. Previous research shows that first year engineering students typically describe social responsibility using phrases such as giving back, helping individuals, and ethical behavior [9]. In this paper we define social consciousness as the recognition of societal needs. As stated in the Engineer's Creed, engineers should strive to "*... place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations"*[10] .

Methods

As women are socialized to be more nurturing and compassionate than men [5][11], the initial hypothesis was that groups that were predominantly female would focus more on helping others while the groups that contained more males would develop projects that would be primarily designed with college students in mind.

Sample

The sample for this study consists of 227 freshman engineering students at Louisiana Tech University enrolled in Engineering Problem Solving III in the spring of 2015. According to academic records, males make up 79 percent of this sample, leaving 21 percent females. The average team size was 2.2 in the five honors sections and 3.7 in the four regular sections.

Data collection

To generate project ideas, students are asked to create a "bug list" following the IDEO design process described in The Art of Innovation by Tom Kelley [12]. Each student records a new bug

for the first seven homework assignments; the problem statement for homework 1 is provided below:

> *Generate bug #1 for your "Bug List." Remember that a bug can be something that doesn't work quite right or that could be improved, something that bothers you, or things that you notice others struggling with. For your homework, please name the bug, write up at least a two sentence description of the bug, and provide pictures when it makes sense to do so. You don't need to try to find a solution to the problem at this point. Try to think of bugs in different categories as you build your bug list. For example, find bugs related to major life activities (recreational, occupational, tasks of daily living, transportation, communication, learning) and bugs affecting special people groups (disabled, senior adults, children).*

For homework 8, student teams compile their bugs to create a team list; the problem statement for homework 8 is provided below:

> *Meet with the other members in your group, and compile a single bug list for your group. Include ALL seven of each group member's bugs. As a group, select the bug you "think" you would like to tackle for your design project, and identify this bug in your homework.*

As an example, a team of three students would combine 7 bugs from each team member into a master list of 21 bugs as a team, and then decide which of these 21 bugs (or a variant thereof) they will tackle as their design project. Each team was instructed to write an abstract that would give an overview of the product. Our data is a result of the analysis of these abstracts.

Abstract analysis

The purpose of the abstract analysis was to identify relationships between the gender composition of the teams and the motivation behind the products they invented. To determine the themes in the data we first read all the abstracts that were submitted. A spreadsheet was used to organize the information collected from the abstracts. While reading each abstract, keywords were chosen based on the products intended purpose and consumer. We then noted the keywords and phrases that occurred most often. Then these words were grouped based on their resemblance to one another. For example, safety, safe, cautious, prevention and protection were grouped together and the abstracts that were included in this group were included in the *Safety* theme. These themes gave us more insight into the motivations behind each group's product. Emergent themes were *Annoying and Frustrating*, *Efficiency and Time Saving*, *Safety*, *Elderly and Disabled*, *Health and Sanitation*, *Forgetfulness*, and *Children*.

Next, their level of social consciousness further categorized the abstracts. Here we define socially conscious projects as those that show a recognition of societal needs and are designed to benefit others. Since we do not have background information on the students that created each product, assumptions had to be made to determine which products would be considered socially conscious. Based on the abstracts submitted, some products were clearly designed with college students in mind while others were not. One group invented a Smart Parking Lot. From the title alone it may seem that this is a product that was not designed with any particular vehicle owner in mind. However, the abstract includes the statement "Student parking is an issue for many

college campuses across the United States… finding open spots could make students late to class or parking in the wrong spot could put fines on students (Group 30, abstract)." Therefore, it is not categorized as a socially conscious product. Group 3 developed a similar product. The Parking Lot System aims to save the driver time by using an LCD screen to display which parking spots are available. The following quote was taken from this group's abstract. "Our system aims to prevent people from going through many filled rows of a parking lot unnecessarily. This system could be used in many applications such as malls, parking garages, theme parks, and hospitals (Group 3, abstract)" The fact that this abstract doesn't implicitly or explicitly suggest use by college students lead this parking system to be categorized as socially conscious. Products that were designed for the elderly, disabled, parents of young children, and professionals were also categorized as socially conscious.

The socially consciousness categories ranged from the most socially conscious groups, labeled *Other*, to the least socially conscious groups, labeled *Self*. Products in the *Other* category addressed issues ranging from child alert systems that allow parent to keep track of their children to mattress pads designed to make hospital stays more comfortable. The *Self* category included products that mainly serve to benefit college students. While some classifications were relatively apparent based on the abstracts submitted, some were not. Many groups developed products that had no designated target consumer. For example, the product *Sort it Out* uses light waves to automatically sort laundry. Since sorting laundry is a frequently occurring event for most people, determining the level of socially consciousness from the abstract alone was difficult. Products like this that could be intended for use by the all individuals regardless of age, occupation, and ability are included in the *Both* category.

Our second objective was to look at the gender composition of the groups. For this reason, we needed to differentiate between groups that were mostly male, mostly female, and evenly mixed. After obtaining the gender of every student in our sample, we used a spreadsheet to quickly tally the overall number of males and females. We also found the number of males and females in each group. Groups that were comprised of over fifty percent males or over fifty percent females were labeled *mostly males* and *mostly females*, respectively. Those with an equal number of males and females were labeled *even*. We then calculated the percentage of men and women within each category and level of social consciousness. The combination of our motivation data with our gender data comprises the findings of the study.

Findings

Seven themes were identified based on the problems the teams attempted to solve. Some abstracts showed evidence of only one theme, but several were categorized as showing two or more themes. The following themes were determined from the list of keywords that occurred most often in the abstracts. Figure 1 shows the percentage of groups that exhibited each theme. As some projects exhibited multiple themes, the total sums to more than 100%.

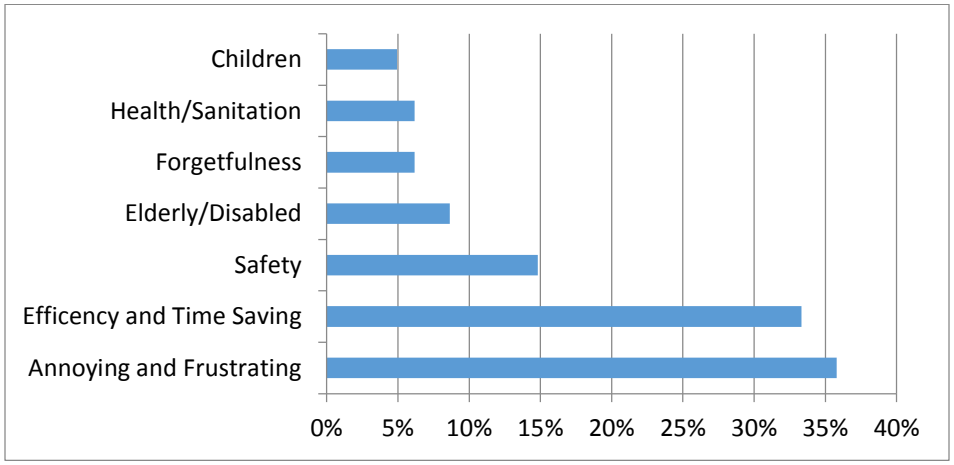

Figure 1: Percentage of groups in each theme

Figure 2 shows the gender of individuals within each theme. As noted above, 79% of the participants were male and 21% were female. The dashed vertical line shows the percentage of females in the population and the solid vertical line represents the percentage of males in the population. Any female bar that extends beyond the dashed line reveals an overrepresentation of females in that theme. Any male bar that extends beyond the solid line reveals an overrepresentation of males in that theme.

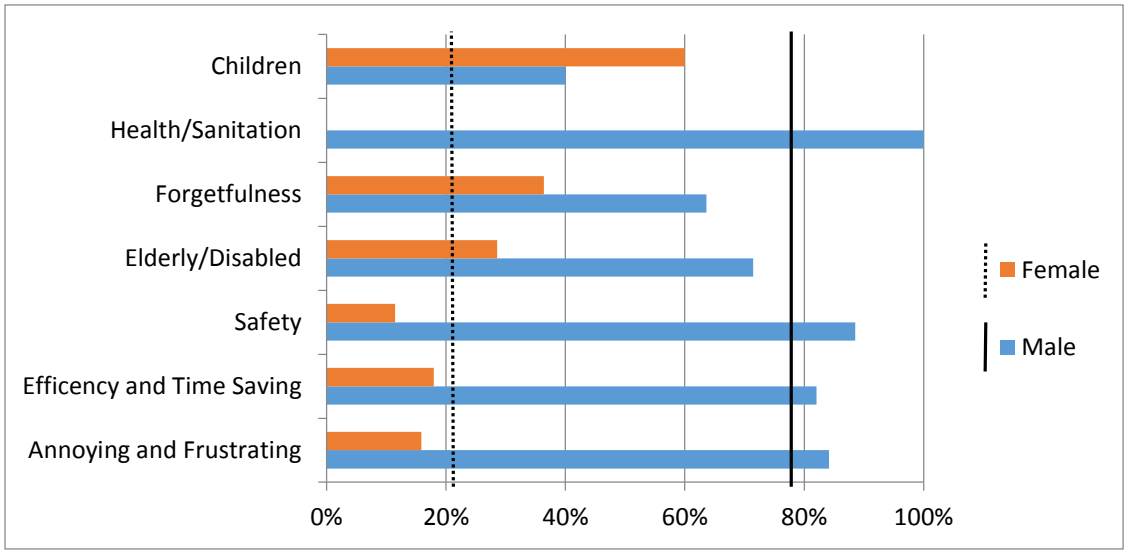

Figure 2: Percentage of males and females within each theme

Figure 3 shows the percentage of each theme that is represented in each gender group For example, the mostly female category shows the percentage of mostly female groups that chose to develop products that fell into each theme. Therefore, the total percentage in each gender category is roughly 100 percent. They do not total to exactly 100 percent because some groups developed products that were place into more than one theme. Overall, 59 (73%) of the 81 teams were mostly male, 10 (12%) were mostly female, and 12 (15%) were even.

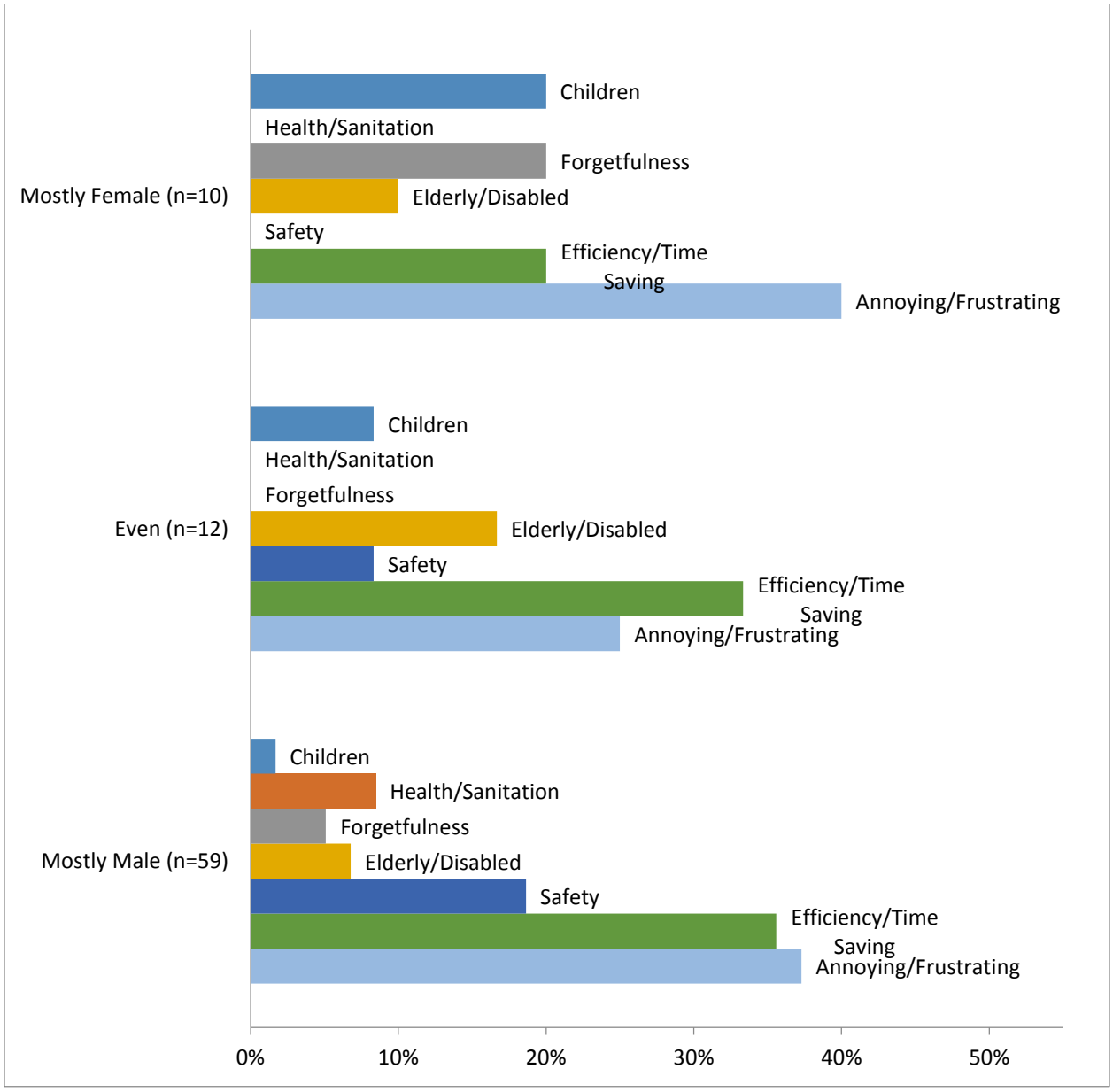

Figure 3: Themes by team gender composition

Annoying/Frustrating Behavior

The theme with the largest number of groups was "Annoying/Frustrating Behavior". This theme consisted of groups who chose to invent a smart product that would make life a little easier for themselves and possibly others. When describing the purpose of their products students in these groups used words such as “annoying”, “frustrating”, and “uncomfortable”. The following quotes were taken from abstracts of groups in this category.

Waking up from an alarm in the morning from a long night can be quite difficult and annoying.

-Smart Alarm Group

...However, most of the time their morning beverage does not stay at the optimal drinking temperature, which can cause a great deal of frustration.

-Heatee Group

Many peoples’ shoes get wet and uncomfortable when it rains.

-Small Dryer Group

These products are intended to give the user temporary relief from specific undesirable events or minor annoyances. Of 81 total groups, 35.8 percent were included in this theme. Of the 29 groups in this theme 75 percent were comprised of mostly male groups, 14.3percent were mostly female, and 10.7 percent were evenly mixed. Males comprised 84.1percent of the total students in this theme and 15.9 percent of the students in this theme were female, thus, males were overrepresented in this category.

Efficiency and Time Saving

The next theme we observed was “Efficiency and Time Saving.” Efficiency and Time Saving were initially two separate groups. However, we chose to combine them because more than half of the groups that were in one category were also found in the other due to similar key words and phrases. Some key words and phrases from these abstracts were “time”, “efficiency”, and “quick”.

Amateur painters and hobbyists constantly mix paint by hand in order to get the colors they need. Not surprisingly, mixing paint by hand is inefficient and time consuming

-Paint Mixer Group

Often, in the morning, we may be running late or just plain lazy. We have a design that could allow one to save precious time in the morning before class or work.

-Voice Controlled Keurig Group

This theme also included products that specifically mentioned how their products build on existing products and decision making.

Drones are used in multiple things, from scouting out buildings and gaining intel to delivering packages. Our goal with this project is to design a tricopter with the former in mind and expand it to more than just military usage.

-Shurikopter Group

Chicken farmers often find that they want to eat their chickens, but are unable to choose because they don't know which chicken lays all of their eggs.

-Chicken Tracker Group

The goals of these products are to reduce the amount of time it takes to carry out a task or make improvements on already existing products. This theme focuses on saving time, energy, or cost while maintaining or improving effectiveness.

Efficiency and Time Saving contained the second highest amount of groups. The Efficiency and Time Saving theme contained 33 percent of the total amount of groups. Of these groups 77.8 percent were mostly male and 7.4 percent were mostly female. The remaining14.8 percent were evenly mixed. Males make up 82.7 percent of the students in this theme and 17.9 percent of the students were female. Males are also overrepresented in this group, though not to the extent as the *Annoying/Frustrating Behavior* theme.

Safety

The *Safety* theme included abstracts that focused on safety and protection. Groups within this theme focused on the safety of people, structures, and equipment. The key word for this theme was "safety". Products in this group ranged from a braking distance calculator to hard hats with hearing protection. There were groups in this theme that did not specifically use the word "safety", but these abstracts did imply that the products were to be used for protection or emergency situations. The following are quotes from abstracts in the *Safety* theme.

Our system detects the emergency broadcast alarm that sounds from the weather radio in the system.

-Emergency Notification in Remote Locations Group

The words safe and skateboard are hardly used in the same breath, we hope our project can make that possible.

-S-Cubed (Smart, Safe, Skateboard) Group

Hearing protection in the manufacturing industry is a safety component that is often overlooked.

-Smart Hard Hat

The *Safety* theme contained 14.8 percent of the groups. Of the groups in this theme 91.7 percent were mostly male and no groups were mostly female. However, two groups (8.3 percent) were even. Males make up 88.6 percent of the students in this theme and 11.4 percent of the students were female.

Forgetfulness

The next theme was forgetfulness. The products in this theme serve to either remind the user or to decrease the negative outcomes of forgetting. Included in this category are the smart toilet that automatically puts the seat down when the toilet is not being used, an RFID which alerts the user when they leave the house without their keys, and locks that can be opened with a mobile app. Key words were "forgot", "forgetting" and "forgotten".

Household electronics are commonly used by people every day. On numerous occasions, many people forget to power off and/or disconnect these electronics which usually results in damage to property.

-Smart Outlet

Many people have had the experience of approaching their door with their arms full, and having to juggle all that they are holding in order to find their keys and open the door, only to find that they had forgotten their keys.

-Puerta Abierta

Of the total number of groups, 6.2 percent were included in this theme. Of the groups in this theme, 60 percent were mostly male, 40 percent were mostly female, and there were no even groups. A total of 63.4 percent of the students in this group were male and 36.4 percent were female. Females were overrepresented in this theme, as they represent only 21.1 of the participants.

Elderly and Disabled

The *Elderly and Disabled* theme consisted of groups whose purpose was to create a product that would somehow assist either the elderly or disabled. These abstracts included words and phrases like "disabled", "limited mobility", and "elderly". We also included abstracts that named specific disabilities and medical conditions.

Blind people have been using the same techniques for navigation for some time. The techniques that they use, such as the simple swing of a pole, do not help them navigate their environment as well as they could

-Blind Assist Group

Some disabled and elderly people run a risk of falling down. If this happens, and they do not have the strength to get up, disaster can follow.

-Life Watch Group

Products in this theme were obviously designing for people other than themselves. This group included a GPS system for the blind, hands-free toothbrush for the disabled, and a vertical cabinet delivery system for people with limited mobility.

This theme contains 8.6 percent of the total groups. There were 57.1 percent mostly male groups, 14.3 percent mostly female groups, and 28.6 percent of the groups in this theme were mixed. Males made up 71.4 percent and females made up 28.6 percent. Again, females are overrepresented.

Health and Sanitation
The Health and Sanitation theme contains products that focus on cleanliness and nutrition. The "Barduino" automatically cleans a toilet seat after use.

An everyday problem that often goes undiscussed is the lack of sanitation in the bathrooms that we use every day.

-Barduino

Clean water is a major concern for third world countries. There are many solutions to this problem, but most are quite expensive.

-Solar Powered Water Distillery System

Of the overall number of groups 6.2 percent were in the Health and Sanitation theme. The groups in this theme were 100 percent comprised of male students.

Children
The last theme is "Children". Keywords were children and parents. This theme included products that help with parenting small children. Child health and safety were prevalent in the abstracts in this category.

In homes that have stairs, doors the child can easily use to exit the house at night, or other hazards, our product would allow parents the peace of mind that if their child were to leave their bedroom at night, they would be aware.

-Child Alert

Unfortunately, many children do not like to drink regular milk, and their parents are forced to develop different flavors.

-Gourmet Milk Mixer

The Children theme contains 4.9 percent of the total number of groups. Of the groups in this theme 25 percent were mostly male, 50 percent were mostly female, and 25 percent were even. Of the students in this theme 40 percent were male and 60 percent were female.

Social Consciousness
We classified social consciousness with three levels, *Both*, *Other*, and *Self*. Of the total number of groups, 8.6 percent were classified as *Self*, 58.0 percent were classified as *Both*, and 33.3 percent were classified as *Other* **(Fig 4)**. The *Self* category contains products that are the least socially conscious. These products were clearly designed with college students in mind. The most socially conscious category, *Other*, contains products that were designed to serve others. Of all of the mostly female groups 20 percent were classified as *Other*. The *Both* category contains products that could fit into either of the previous categories. These three categories of social consciousness were further classified by the gender composition in Figure 5.

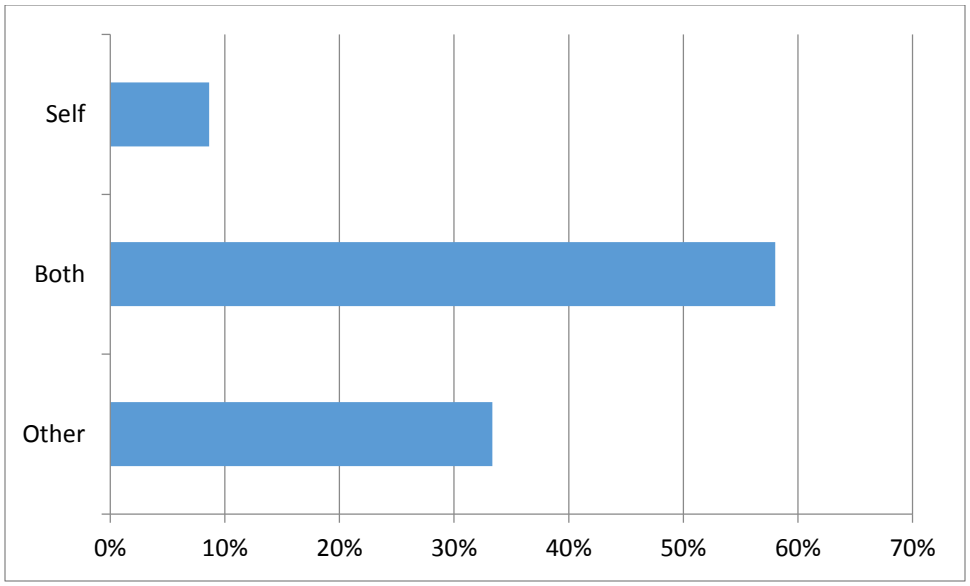

Figure 4: Percentage of projects in each social consciousness level

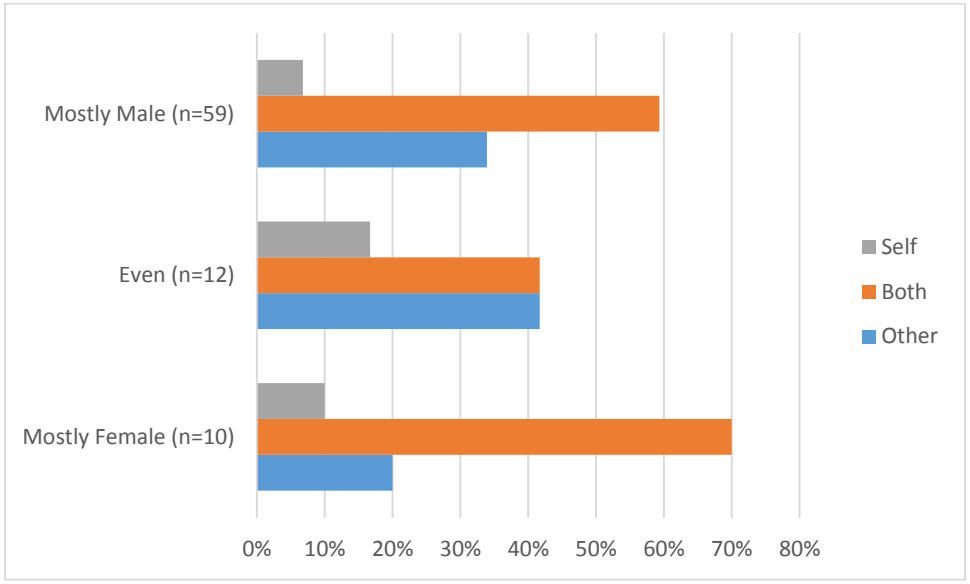

Figure 5: Group social consciousness level by group gender composition

Discussion

Themes

The most prevalent theme in this analysis was *Annoying and Frustrating* (**Fig. 1**). At the beginning of the course students are instructed to come up with a "bug list". The bug list is essentially a list of things that bother you. This list starts the brainstorm process for their smart products. The bug list is likely a big part of the reason that the *Annoying and Frustrating* theme is the largest with 36 percent of the total number of groups. About 84% of the individuals in this theme were male (**Fig. 2**). This is a high percentage in and of itself, but we must take into

consideration that the sample used for the analysis was 79% male. Consequently, this "high" percentage was expected. *Annoying and Frustrating* was the most frequent theme among mostly female and mostly male groups (40% and 37%, respectively), but was less frequent among evenly mixed groups (25%) (**Fig. 3**).

The overall popularity of the *Efficiency and Time Saving* theme (33%) was also anticipated. College students frequently attempt to meet deadlines, arrive to class promptly, and find time for a social life. Therefore, the need to save time or work faster is likely to have crossed the mind of every college student at some point. Again, the percentage of males (82%) was expected due to the large amount of males in the sample (**Fig. 2**). *Efficiency and Time Saving* was the most frequent theme among evenly mixed groups (33%). It was also a close second among mostly male groups (36%).

The least common themes in the analysis were *Health and Sanitation* and *Children* with 6% and 5% respectively (**Fig. 1**). The low amount of products focused on health may be due to the fact that college students are younger and not yet concerned with health issues and nutrition. The *Children* theme may contain fewer groups because most college students are not conscious of the demands of parenthood and child-rearing. The *Health and Sanitation* theme contained products that focused on nutrition, anti-odor management, and cleanliness. We expected cleanliness and nutrition to contain mostly female students because of the notion that women are more likely to be concerned with how things smell, what they eat, and the cleanliness of their surroundings. Surprisingly, this was not the case. Not only was this theme dominated by mostly male groups, but there was no female presence in any of the groups in this theme (**Fig. 2**). With a total of five groups and a total of fourteen students, all of the students in all of the groups were male. Our last theme, *Children*, contained the least number of groups. This theme was the only one that contained more mostly female groups than mostly male groups (**Fig. 3**). Twenty-five percent of the groups in this theme were mostly male, fifty percent were mostly female, and twenty-five percent contained one male and one female. This too was expected because women are socialized to be more nurturing and compassionate than men [13].

The themes *Safety* and *Elderly and Disabled* also reveal results worth further discussion. The *Safety* theme is composed of groups that focus on the safety on individuals and structures. Of all the groups, 15 percent were included in this theme (**Fig. 1**). The mostly male groups were dominant in this theme with 91.7 percent of the total number of groups, and there were no groups that were mostly female (**Fig. 3**). There was one group in this theme that was evenly mixed with one male and one female. This suggests that male students are more concerned with safety than female students. The *Elderly and Disabled* theme contains 8.6 percent of the groups (**Fig. 1**). Of the mostly female groups 10 percent chose products for the elderly and disabled whereas of the mostly male groups 7 percent designed products for the elderly and disabled. As stated in our hypothesis, we expected more women to be focused on helping others. Therefore, it was not surprising to see that the mostly female groups had a higher prevalence of this theme. The evenly mixed groups had the highest prevalence with 17% of their total number of groups being classified as *Elderly and Disabled* (**Fig. 3**).

Self v. Other

Our abstract analysis revealed that most of the abstracts submitted did not clearly fit into the *Self* category or the *Other* category. Fifty-eight percent of the abstracts were classified as *Both.* In order to get a clearer picture of the level of social consciousness in reference to gender

composition of each group we will focus on the remaining 42 percent of the abstracts that we could identify as *Self* or *Other* (**Fig. 4**). Counter to our hypothesis, 34 percent of the mostly male groups developed a socially conscious product, and only 20 percent of the mostly female groups developed socially conscious product. However, 42 percent of the evenly mixed groups developed a socially conscious product (**Fig. 5**). This finding highlights the importance of diversity and supports Vest's statement that diversity is necessary to meet societal needs [14].

Conclusion

This study revealed that the college students in our sample are most concerned with annoying situations and saving time. They are generally least concerned with health and child care. We also see that though the child care theme was the least popular, the greatest percentage of females and mostly female groups were found in this theme. The *Health and Sanitation* and *Safety* themes were dominated by male or mostly male groups. With further study, these types of findings could impact recruitment techniques for male and female engineering students. . When addressing female students it may be beneficial to emphasis the impacts that engineering has on child care, forgetfulness, and frustrating events because these themes were the most prevalent in mostly female groups. When addressing males, engineering in terms of health and safety, sanitation, and efficiency are more likely to be of interest. Contrary to our hypothesis, results of this study show that a larger percentage of mostly male groups chose products that were socially conscious than mostly female groups. However, the evenly mixed groups were the most represented in the socially conscious category. This finding may suggest that gender diversity in engineering projects is more likely to result in ideas that benefit society as a whole because balanced teams are better tuned to solve socially conscious problems.

Acknowledgement

The authors would like to thank Lindsey Nelson for her assistance in the early stages of this project.

References

[1] H. Zandvoort, "Preparing engineers for social responsibility," *Eur. J. Eng. Educ.*, vol. 33, no. 2, pp. 133–140, May 2008.
[2] J. R. Lohmann, H. A. Rollins, and J. Joseph Hoey, "Defining, developing and assessing global competence in engineers," *Eur. J. Eng. Educ.*, vol. 31, no. 01, pp. 119–131, 2006.
[3] "Criteria for Accrediting Engineering Programs, 2016 – 2017 | ABET." .
[4] S. Beder, "Beyond technicalities: Expanding engineering thinking," *J. Prof. Issues Eng. Educ. Pract.*, 1999.
[5] N. E. Canney and A. R. Bielefeldt, "Gender differences in the social responsibility attitudes of engineering students and how they change over time," *J. Women Minor. Sci. Eng.*, vol. 21, no. 3, 2015.
[6] S. A. Hewlett and others, The Athena factor: Reversing the brain drain in science, engineering, and technology. Harvard Business School Watertown, MA, 2008.
[7] H. M. Matusovich, R. A. Streveler, and R. L. Miller, "Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values," *J. Eng. Educ.*, vol. 99, no. 4, pp. 289–303, 2010.
[8] C. Hill, C. Corbett, and A. St Rose, Why so few? Women in Science, Technology, Engineering, and Mathematics. ERIC, 2010.

[9] G. A. Rulifson, A. Bielefeldt, and W. Thomas, "Understanding of Social Responsibility by First Year Engineering Students: Ethical Foundations and Courses," in *American Society for Engineering Education Conference and Exposition Proceedings*, 2014.
[10] "Engineers' Creed | National Society of Professional Engineers." [Online]. Available: http://www.nspe.org/resources/ethics/code-ethics/engineers-creed. [Accessed: 19-Apr-2016].
[11] C. Giligan, "In a different voice," *Camb. Harv. UP*, 1982.
[12] T. Kelly and J. Littman, "The art of innovation," *N. Y. Broadway Bus.*, 2001.
[13] A. H. Eagly and V. J. Steffen, "Gender Stereotypes, Occupational Roles, and Beliefs about Part-Time Employees," *Psychol. Women Q.*, vol. 10, no. 3, pp. 252–262, 1986.
[14] C. M. Vest, "Educating engineers for 2020 and beyond," *Natl. Acad. Eng.*, 2005.