Measuring the Benefit of Service Oriented Student Design Projects

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Abstract – The State of Tennessee Department of Education provides grant support to the University of Tennessee at Chattanooga (UTC) to design, prototype, test, evaluate and disseminate products, procedures, and services that apply adaptive and assistive technologies to children with special needs. Eight to sixteen projects have been completed by freshman and upper level students each year since the fall of 2005. The academic outcome of these projects is an opportunity for students to experience the design process, aid someone’s ability to be independent, and learn how engineering can benefit our society. The students who participate in these projects informally express they are motivated by knowing they have designed a device that can improve the life of a child. A recent formal survey of those students who have participated in these projects confirms this statement. It also presents some interesting findings with respect to why students choose particular projects to participate in and what they believe they have learned from the projects that is most beneficial to them.

Index Terms – assistive technology, community service projects, freshman design projects, societal context

INTRODUCTION

The State of Tennessee Department of Education provides grant support to the University of Tennessee at Chattanooga (UTC) to design, prototype, test, evaluate and disseminate products, procedures, and services that apply adaptive and assistive technologies to children with special needs and their families and service providers. The program at UTC embeds this activity in two courses – the freshman introduction to engineering design (IED) course and the junior/senior interdisciplinary design course sequence.

An emphasis of the UTC Technology Designed to Benefit (TDB) program is the completion of 8 to 15 small projects a year by freshman students and 1 to 2 more complex projects by junior and senior students. For both the freshmen and upperclassmen projects, the academic outcome is an opportunity for students to experience the design process, aid someone’s ability to be independent, and learn how engineering can benefit our society. But what is the reaction of the students to these opportunities? What benefits do the students believe they receive from these projects? What do the students believe they learn from the projects? What impact do these projects have on the students’ academic or professional paths?

The students who participate in these projects informally express they are motivated by knowing they have designed a device that can improve the life of a child. But to more formally determine the impact of service oriented design projects, a survey was completed by the TDB project participants from the fall of 2005 to the fall of 2007. The students were asked to respond to multiple choice and short answer questions. This paper presents the results of this survey including an overview of the students’ reactions and a comparison between a number of demographics (such as gender, age, and academic class).

PRESENT UNDERSTANDING OF SOCIETAL CONCERNS

ABET Engineering Criteria includes in its list of course outcomes that students should receive the broad education necessary to understand the impact of engineering solutions in a global and societal context [1]. This appears to be an important and reasonable expected outcome of our engineering programs. However, ABET does not state how the programs should define or interpret the terms “global context” and “societal context.” These concepts are interpreted in varying ways depending on how the program wants to address the outcome.

What is known is that the U.S. and world demographics are changing which is heightening various societal issues. For example, the National Academy of Engineering of the National Academies states that the aging U.S. population makes greater demands on the health care system, heightens labor force tensions, and increases political instability – all societal issues. In addition it identifies a trend in developing countries that has global as well as societal impacts – more than 50 percent of the world’s population could be less than 18 years old in 2020 [2].

The present engineering education literature does not provide much background on defining “societal context.” Mansfield, in his paper “Gauging Societal Concerns,” defines a societal concern as a “collective subjective measure of individuals’ concern within society” [3]. Tomlinson adds that societal concerns or problems are large and complex and difficult to model in traditional ways. Richardson and Kostyniuk recognize that the public drives societal issues so they use a public participation process to collect people’s views and ensure society is involved in the topic decision analysis [5].
The National Academy of Engineering recognizes that societal concerns are not easy to address due to their complexity. However, they believe that engineers must learn to recognize the role of societal concerns on design and manufacturing because it is not only the technical challenges that drive the design and decision processes, but the legal, market, political, environmental, health, safety, economic, etc. issues may drive the process as well [2].

Sample Initiatives

Some engineering programs emphasize a specific societal concern when addressing a course project or decision making topic. For example, Handy et al has integrated sustainability and green manufacturing topics into a manufacturing processes course [6]. The specific societal issue is human health impact and it is their belief that integrating environmental sustainability into the curriculum addresses the role of engineering stewardship. They have embedded the topic in the discussions of various manufacturing processes and have included questions on exams to ensure that students are not only introduced to the topic but must try to ingrain the concepts.

Other programs address societal concerns through the application of design projects. Daniels et al have IT students improve a situation in a hospital to introduce them to the impact of IT on society. This relationship is easy for students to recognize because they see applications in a hospital as activities that may directly benefit society [7].

Service learning projects, those that apply academic principles to service a specific community population, are another means some programs use to introduce students to the relationship between engineering and social issues [8] [9]. These projects, which are extensively used by many engineering programs, such as Columbia University’s, challenge students to communicate within and to understand unfamiliar societal conditions.

Outcomes of Initiatives

Some programs are finding that projects emphasizing community and social impact are attracting female engineering students. There is evidence that having a positive impact on others’ lives is a major factor in career choice for females and some under-represented groups. For example, 25 percent of the participants in the Engineering Projects in Community Service (EPICS) program at Purdue University have been women [10]. This program creates a long-term relationship between the local community not-for-profit organizations (partners) and engineering students (teams of 10 to 20 students across the four academic years) to solve the partner’s technology-based problems.

APPLYING SOCIETAL CONTEXT AT UTC

UTC, like many engineering programs, chooses to address the societal learning objectives within a course and design project experiences. Specific interdisciplinary design projects (involving some combination of chemical, civil, electrical, environmental, industrial, and mechanical engineering students) occur during the freshman, junior, and senior academic years. The freshman projects are embedded in the Introduction to Engineering Design (IED) course. The junior and senior projects are the main focus of the sequential Interdisciplinary Design I and II courses. Presently over one-half of the freshman projects and one fourth of the upper-level projects each semester address societal issues.

For example, the IED and the Interdisciplinary Design students participate in projects supported by the TDB project funded by the Tennessee Department of Education. The focus of these projects is assistive technology for toddlers and young children (age birth to 6 years). Signal Centers’ Department of Assistive Technology is the project partner. Projects support children, families, and counselors in Chattanooga as well as the surrounding counties. During the 2005 – 2006 academic year 9 projects were completed and delivered to the children and centers. The 2006 – 2007 year saw 14 projects delivered. The 2007 - 2008 will see over 15 projects delivered.

Molly Littleton, Director of the Assistive Technology Group at Signal Centers in Chattanooga, Tennessee and TDB project member, identifies possible projects from families and children with needs. Following consultation with the course instructor(s), she submits proposals of those projects for project team consideration. Ms. Littleton then acts as project consultant for each of the projects, helping the student teams contact the customers, including the therapists, teachers, and impacted children and families. The course instructor supports the technical needs of the projects.

Project Examples

A recent freshmen TDB project involved creating a means to position a Springboard communication device for use by a child of very small stature and limited freedom of movement. Prior to project completion someone was needed to hold the Springboard device for the child while she used the device. The child and teachers needed a custom-built mount system that adapts to the child’s wheelchair, her group activity wooden chair, and her floor activity.

The student designed Springboard Communication Device System (SCDS) is made of Lexan, aluminum, and Delrin (a high quality, smooth plastic). The device, as shown in Figure 1.0, resembles a tray on a high chair, except a Delrin “strip and track” is included down the center of the tray to allow the block...
that holds the springboard to slide. At the end of the long Delrin platform is a shorter piece of Delrin that swings under the tray to allow storage for the Springboard mount and space for writing, drawing, or coloring. Both Delrin pieces have locking pins to hold the block and Springboard in place.

Another freshman TDB project, the Multi-Switch Mount System (MSMS), was developed during the spring 2006 semester for a child at Signal Centers with multiple disabilities who frequently pulls or knocks mounted or placed switches off his tray. The MSMS secures two types of switches – a gum ball switch and two talking picture frames – to a tray that mounts to a wheelchair.

The MSMS, as shown in Figure 2.0, is made from acrylic. An acetyl dome covers and secures the large gum ball switch. In addition, it has two smaller mounts that enclose the talking picture frame switches. The smaller mounts are made from Delrin. The switches are positioned at 45 degree angles to the child to aid usability. The tray clamps to the arms of the wheelchair.

A last TDB project example is the Bumbo© Chair table designed and built by a fall 2007 freshman IED project team for a Signal Centers facility located in Athens, TN. This table is made from one-half inch high density polyethylene. The stainless steel detachable table legs are 2 3/8 inch in diameter. They are removable and adjust to ensure the table is balanced when on an uneven surface. Figure 3.0 illustrates the use of the table with children seated in Bumbo© chairs. These children were previously unable to play, share, and socialize in this interactive style. The table can be used with up to 4 children.

**Project Outcomes**

The National Academy of Engineering believes that engineers must learn to recognize the role of societal concerns on design and manufacturing and to recognize the role engineering may play in society. The engineering students supporting the TDB projects have the opportunity to directly view and participate in how their designs impact a single child, a child’s family, or an entire classroom of children with special abilities. The engineering students who participate in these projects express that they are motivated by knowing that what they are designing is improving the life of a child or the lives of a number of children. They realize that engineers can have a significant role in helping make a portion of our population, which not too many years ago had to live in isolated communities, have independent and contributing lives.

Interestingly, 80% of the TDB projects result in a delivered product. More interesting is that the students, if unable to complete the project to the customer’s satisfaction within the IED semester, continue to work on the project into the next semester even though they have successfully completed the IED course.

**SUBSTANTIATING IMPACT OF THE TDB PROJECTS**

Although the above outcomes qualitatively indicate that students are learning about the role of engineering in society and its impact, it is not conclusive. Thus, the TDB project members conducted a survey of all students who participated in the IED course for the 2005, 2006, 2007 fall semesters and the 2006 and 2007 spring semesters (approximately 200 students.) The goal was to determine the impact of the projects by understanding

- the reaction of students to the projects
- the benefits students believe they receive from the projects
- what students believe they learned from the projects
- what impact students believe these projects have on their academic or professional paths

The survey was developed by the TDB project team and validated by the UTC Center of Applied Social Research. It was web-based and delivered using students’ university e-mail addresses. The software used to create, present, and deliver the survey ensured that the responses were anonymous. The students had two weeks to respond. Forty-six students responded to the survey.

**Findings**

Of the forty-six students who responded to the survey, eight (17%) are female, 39 (85%) are Caucasian, 4 (9%) are African American, and 4 (9%) are Asian. The distribution of respondent age at the time of taking the ENGR 185 course is typical for engineering courses at UTC (see Figure 4.0). This is because many students transfer from a community college or are returning students choosing a second career.
The represented distribution between the engineering disciplines is shown in Figure 5.0. This distribution parallels the distribution of students enrolled in UTC’s engineering programs. The “other” category corresponds to those students who are no longer enrolled in an engineering program.

The students surveyed had the opportunity to participate in four different types of projects, two of which represent community service projects – the assistive technology (AT) projects and the Chattanooga community (CC) projects. The CC projects were sponsored by a community service organization. The remaining two project types – Engineering Faculty projects and UTC ENGR upper level projects – were internally sponsored. They supported faculty research, course, or lab needs (FP) or the Junior/Senior design projects (JSP), such as the MiniBaja. As shown in Figure 6.0, most respondents supported the AT projects. This is consistent with the course project offerings – each semester 50% to 80% of the projects are AT projects.

The students in ENGR 185 choose their projects from a list of possible projects. They are introduced to the needs and customers of each project and then are asked to immediately sign up for one of the projects. The Pareto chart in Figure 9.0 illustrates that the most popular reasons for choosing a project are that it is interesting and that it may benefit someone. Over 30 or 65% of the respondents chose one or both of these responses. (Students were asked to check all that apply.)

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The students surveyed represent the six semesters for which the TDB projects (AT) have been offered. Figure 7.0 shows that the highest percentage of respondents represents the most recently completed semester (fall 07).
Of interest is how gender affects project choice. Figure 10.0 illustrates that almost 100% of the females and males based their project choice on whether the project may benefit someone. Interestingly, the males were split almost evenly as to choosing a project based on its interest to them. The females appeared not to take this into account.

![Gender Influence on Project Selection](image)

When students were asked what they expected or wanted to gain from their chosen project, most students (94%) stated they wanted to get engineering design experience. As expected many (66%) also stated they wanted to complete the course requirements. Obtaining team work and solids modeling experience were also popular expectations (66% and 64% of respondents, respectively). Interestingly, 70% of the students also wanted a chance to benefit someone. Were the students expectations met? 96% said “yes”. In fact, 37% of the students stated that helping someone was what they found most fulfilling about their project. Also, 43% of the students stated that the project had an impact on their pursuit of a career in engineering or engineering technology. Of this 43%, 75% stated that the project had a positive impact.

![Learning from Project](image)

When the students were asked what they believe they learned from their project that was most important, 27 of the students (59%) insinuated that learning about design or working in teams was the most important (see Figure 11.0). Similarly learning or experiencing aspects of the design process or team work were what the students thought were the most important benefits received from the project.

Table 1 below summarizes the student responses (overall and categorized by male/female) to questions that provide an indication of their general reaction to the projects as well as whether the projects clarified their understanding of the engineer’s role in society.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>na</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Did project improve your understanding of what engineers do?</td>
<td>84</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>2. Did project expand your knowledge of how engineers benefit society?</td>
<td>91</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>3. Would you recommend project to other ENGR 185 students?</td>
<td>92</td>
<td>88</td>
<td>12</td>
</tr>
<tr>
<td>4. Based on project experience would you include service projects in your career plans?</td>
<td>73</td>
<td>9</td>
<td>18</td>
</tr>
</tbody>
</table>

Note: All values are in percent (%). M=male, F=female.

As the table shows, there is a consensus that the projects improved student understanding of (1) what engineers do and (2) how an engineer can benefit society. In fact, most students who worked on a community service project would consider applying their skills in an engineering position that addresses service projects.

Analysis of Findings

Two-sample proportion tests of data in Table 1 (at the 95% confidence level) indicate there is significant difference between the proportion of students responding “yes” to questions 2 and 3 when considering gender (females are more likely to respond “yes”). Two-sample proportion tests on the data shown in Figure 10.0 (at the 95% confidence level) indicate that there is no significant difference between the proportion of students choosing a project due to a student’s interest in it or its possibility of benefiting someone, when considering gender. But, the number of female students responding to the survey is small. Thus, at this time these tests can not be considered statistically significant. It does appear, however, that students do pick projects based on their possible ability to benefit someone.

The survey results address the impact of the community service projects on student learning. First, the students have a positive reaction to the projects. They find them worthwhile and would recommend that others participate in them. One student stated that “It ensured me that engineering is the fit for me. The project was the best learning experience that I have ever had, and it was
definitely one of the most rewarding things that I have done in college.” Another student stated “It allowed me to explore my creative side and see that I can think outside of the box. I have always thought that I would struggle as an engineer because of a lack of creativity. However thanks to this project I now see that I do have creativity.”

Second, the benefits students believe they received from the projects – design and team work experience – are inline with course objectives. It is gratifying that students also believe these benefits are the most important attributes they learned from the project.

Finally, the projects have an impact on students with respect to helping them choose their career path. One student stated “The project I worked on prepared me for the type of work I now am sure I am interested in pursuing.” Another student stated “It affirmed my interest in the field.” A small percentage of the responses (15%) stated that their experience on the project negatively impacted their pursuing an engineering career. However, when the comments were reviewed, it was found that most of these comments did not indicate a negative experience with the project. Instead it was specifics of the course work load or team experience that resulted in the negative reaction.

CONCLUSION

Though the data set is presently too small to produce conclusive results, the data does indicate an overwhelming positive recognition that the assistive technology and community based projects have improved student understanding of what engineers do. In particular, the indication that community service projects have expanded the students’ knowledge of how engineers may benefit society is reassuring. Also reassuring is that the projects are motivators to help students learn the design process and experience working in teams. Lund and Budny comment that the role of service oriented projects should be to motivate the learning as well as introduce the “soft skills” such as the role of engineering in a global and societal context [11].

The initial survey also indicates (as do previous studies) that females find the service oriented projects attractive. When choosing a project, the surveyed female students placed much weight on the ability of a project to benefit someone. Presently only 12% of the engineering students at UTC are female. The program desires to use the service oriented projects as a tool to attract females to the engineering program.

The authors plan on repeating the survey annually in the hope of creating appropriate statistically significant findings. The timing of the survey is important to separate student course reactions from project reactions.

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REFERENCES


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