AC 2011-1285: SERVICE-LEARNING VS. LEARNING SERVICE IN FIRST-YEAR ENGINEERING: IF WE CANNOT CONDUCT FIRST-HAND SERVICE PROJECTS, IS IT STILL OF VALUE?

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Service-Learning vs. Learning Service in First-year Engineering: If We Cannot Conduct First-Hand Service Projects, is it Still of Value?

Abstract

The literature and 10 to 15 years of practice at many universities have clearly demonstrated that Service Learning provides benefits to both the community and the students' learning with increased levels of social responsibility. [1,4,7,20] In the College of Engineering at Northeastern University, the integration of service-learning projects in a first-year Introduction to Engineering Design course has been considered for a number of years. Implementation by first-year faculty would require coordination and development of nearly 160 projects involving multiple community partners providing a wide range of services. Before embarking on this major undertaking of first-hand service learning, the faculty developed major design projects with service and humanitarian foci –referred to as *service-oriented* projects– for students to work on in teams. The research analyzes the change in students' attitudes, and reveals that learning service through selected project types has an impact similar to that of service learning. Results show that there are some changes in attitudes and future planned activities after participation in these projects, similar to those seen in hands-on service-learning environments. In addition, comparisons of students on non-service focused projects to those on actual service-learning or service-oriented projects show they are significantly less affected in terms of concern for social problems or that non-profit work is a true venue for engineering work.

Introduction and Background Literature

Service Learning and Service-Oriented Projects. Service learning as defined by the National Service Learning Clearinghouse[15] is "a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities." Building from this definition, we can identify specific elements of service learning which are identified in the book *Service Learning: Engineering in your Community*[9] as possessing the following elements related to engineering:

- *Service:* Service to an underserved area or people. This can be direct, and ongoing, or project-based, involve hands-on aspects or research and analysis.
- *Academic Content:* A means to learn engineering principles more effectively, the service is linked to the course content and study requirements.
- *Partnerships and Reciprocity:* involving students, faculty, the community and possibly companies, and when done well, all partners contribute to the work, receive benefits from the work and learn from the work.

- *Mutual Learning:* Based on mutual respect, students learn from expertise and knowledge in the community partners, as the partners can learn about engineering and technology. Deeper levels of learning can be gained as they work together and impact each other.
- *Analysis and Reflection:* This is a key component and vital to connecting the service to the academic content, in order to really gain the most benefit. This extends from relating the academic content to the service, the implications of the social context of the work, all the way to seeing the role of engineering in society.

The learning benefits are also discussed in the book by Lima. "The connection to the community can provide motivation and a context. These have been cited as critical learning components by cognitive scientists who study how people learn." [9] Learners are motivated by being able to see the problems more clearly and the impact they may have as they solve these problems. In addition, many of the desired attributes of an engineer are developed through service-learning projects, and many ABET outcomes can be mapped to results and tasks in these projects. But many of these same benefits are accomplished when students are involved in service-oriented projects, even if these are not direct or experiential service-learning projects.

As engineering educators, it is important to not only teach theory to our students but to also promote the notion that engineering provides an avenue to help others. We would like to develop a sense of caring in our students and foster the idea that as engineers they have a real opportunity to make a difference in the lives of others. With these goals in mind, we often jump into the process of trying to integrate service-learning projects into a classroom only to realize later that the extra coordination and logistics required are extensive. In contrast to service learning, a service-oriented project will possess virtually all of the same elements but without the need to actually interact with the community thus eliminating most of the challenges of coordination.

Service Projects at Engineering Universities. In recent years, many have attempted to integrate projects with the hopes of improving their class quality, student experiences, and retention rates. Large-scale programs have been set up such as the ROXIE project at Virginia Tech which paired upwards of 87 community partners with 185 first-year design teams.[10] Purdue University instituted its EPICS program "Engineering Projects in Community Service" with 400 students forming 25 multidisciplinary teams.[3] Colorado School of Mines also has an EPICS program, originally based on Purdue's initiative.[25] Cal Poly Pomona established an Engineering Service Learning Institute (ESLI) with NSF support to integrate service learning in the engineering curriculum and developed service projects such as a Voice Controlled Wheelchair and Devices for Developmentally Disabled.[13] Faculty at the University of Michigan using several statistical tests such as ANOVA, stepwise and multiple regression analysis showed that the overall response of students participating in a service-learning semester was significantly higher than previous non-service-learning semesters, indicating a higher sense of satisfaction with the course and instructor.[11] In a first-year hands-on engineering design class at the University of Colorado they studied the effects of incorporating service learning into the class on first-to-second year

retention.[16] Participation in this class appears to be improving year one to year two retention, although the authors state they were unable to see any clear statistical difference for the service-learning sections vs. total class data.

In a discussion of student attitudes surrounding service learning and how projects may influence these attitudes, it is interesting to see how different engineering schools present service-learning opportunities to their students and to see if they are at all tailored to engineering and to first-year programs. To gain insight into practices at major U.S. schools, a survey of school websites was conducted, searching primarily for 'service learning' and then attempting to see what was being done and where. To narrow the list of survey schools, the survey was limited to programs offered at the so-called 'top' engineering Universities. One arbiter of 'top' schools is the annual list from U.S. News and World Report magazine of the Best Colleges in Engineering. The 2011 list consists of MIT, Stanford, UC Berkeley, Cal Tech, Georgia Tech, University of Illinois, University of Michigan, Carnegie Mellon, Cornell, and Purdue University.[23]

Of these ten, it appears that only Purdue has a formal program as mention previously, EPICS, aimed at involving first year engineering students in service-learning projects.[18] Some 400 students over 20 departments working in 25 teams participated in projects during the 2004 academic year. To date, approximately 2000 students have had experiential learning through the Purdue program.

The balance of the nine other schools has a variety of other methods and means to expose students to world service issues. It does not appear that any school has a targeted approach solely for first-year students. Nor do all the schools have organizations or service-learning courses strictly aimed at engineering education, at least not that were clear from their web sites. As many of the schools are diverse university communities, the courses and projects tend be multidisciplinary and non-engineering based. The methods at these schools range from specific stand-alone courses[14,21] to schools that have designated 'centers' for service-based work.[2,6,8,19,22] The centers appear to be separate institutional organizations, often funded by major outside donors, that have permanent staff often interacting with community-based non-profit groups to effect change. Students are then added to projects and are able to participate and learn through these community outreach endeavors.

Half of the schools researched have alliances with non-profit organizations, although the schools do not all have dedicated 'centers' as part of the overarching infrastructure. MIT started its own non-profit group as an outgrowth of an earlier set of course projects which grew into a sustained external effort.[14] Others have outreach into local existing groups and have partnered with them.[2,5,6,8] Cal Tech has an engineering-based course that has focused entirely on a community in Guatemala and is annually working on incremental community improvements in that dedicated locale.[17]

The overview above indicates that the top ten schools are all engaged in service learning with varying degrees of infrastructure and breadth. However, it appears that engagement of first-year engineering students is not a focus of the greater majority of these programs.

First-year Service Projects. Project selection in a first-year engineering design course is critical to a successful outcome. Lund and Budny point out that a fundamental challenge in developing a fulfilling and rewarding experience for each student is the identification of appropriate community partners and projects.[12] They note that their freshmen engineering students, with a limited skill set, have a tendency to select projects which are clearly marked as engineering-related, often resulting in unattainable goals leading to unhappy community partners and discouraged students.

The fit for service or humanitarian-type projects and first-year engineering design courses has been outlined and discussed in many places, including the text on engineering service learning authored by Lima.[9] One chapter in this textbook maps the engineering design method for service learning. The method outlined matches other design processes, with steps of problem identification, developing specifications, concepts, details, implementation, and reflection and redesign; these match the design process used in our own first-year engineering design course. The project profiles also align with the projects we offer the students defined as *service* and *humanitarian* projects. For example, the list of projects from the book and other literature include environmental projects, along with other topics such as playgrounds, hospitals or clinic projects, agricultural machinery and equipment for the disabled. The projects offered in our course can be organized into similar categories; there are health-related projects, equipment for third world countries such as water heaters, or stoves, emergency relief equipment, devices for child safety, environmental projects such as river cleanup, and alternative power generation, and aids for disabled and handicapped such as mass transit access and vehicle assist devices. The service to humanity is clearly defined in all with only the major difference being the direct contact with the community they are serving (See Appendix C for complete list).

In the College of Engineering at Northeastern University, the integration of service-learning projects in a first-year Introduction to Engineering Design course has been under consideration for a number of years. But with 500+ first-year students, the management and administration of service-learning projects seemed daunting in the absence of significant resources provided to support the effort. In order to be implemented, the first-year faculty would have to coordinate and develop upwards of 160 projects that would involve many community partners. To assess the merits of such an undertaking, it was decided to first develop projects with a theme of having a societal benefit; these would be design project topics with humanitarian and service focus, projects that have an impact in their local community, or even a further global impact.

Some History of the Involved Course. More than ten years ago, as the first-year Engineering Design course was being developed and improved, the major design project continued to be a

key element. This project was begun around 7 weeks into the semester, and projects chosen by the majority of student groups were mostly product design based. The students followed the design process in teams, and designed on paper a product or process, with a final report and presentation at the end of the semester. Example projects –which were primarily student selected– were safety devices, improvements on products, sports devices, new products the students were interested in, or products that the students selected for personal interest or help. There were safety ladders, pet feeders, soccer ball returns, storage systems for dorm rooms, classroom redesign, and new alarm clocks.

The instructors of the design course began to consider projects with more impact and that have a larger scope. They developed a list of humanitarian and service-based projects which has grown and been developed over the years. A current version is included in the Appendix C. The projects were now all focused on helping others, either here in their own community or globally, such as improving water conservation in agriculture, disaster relief, products for the disabled or handicapped, environmental, green, or conservation projects, and child or personal safety products. Students selected a project in teams from an instructor-provided list. Some classes worked on one topic only while others would have two groups working on the same topic or even having many groups work on several different topics. The students seemed to be as enthusiastic about these projects as those previously self-selected and the project quality was as high as before, if not higher, as assessed by the instructors. The instructors saw better research, better development of alternatives and many well-designed solutions. It was time to assess the effects that these projects have on our students.

Motivation and Survey Method

As noted, the literature and 10 to 15 years of practice at many universities have clearly demonstrated that service learning provides benefits to both the community and the students' learning with increased levels of social responsibility.[1,4,7,20] As stated in the reasons above, before committing to developing a service-learning program, it was decided to pilot the integration of service-oriented projects first. The question, then, is do these projects affect the students' in a ways similar to those of service learning? After working on these service-oriented projects, do the students have a changed perspective on engineering that includes helping and serving others? To answer these questions, a pre- and post- project survey was given to all first-year engineering students to assess whether their focus had been impacted as a result of working on and seeing presentations of engineering design in service-oriented projects.

The dual-phase survey was entitled 'Engineering in Society', and was administered to more than 500 first-year students in all Engineering Design classes. The pre-survey was given early in the semester before the design projects were started (Appendix A). The first part of the pre-survey assessed their familiarity with current events locally and globally, and the sources of their information, along with basic demographics and selected majors in engineering. This was followed by a series of questions on students' knowledge of human needs, organizations, and

services. The bulk of the survey focused on identifying engineering roles such as: engineers produce products, engineers help improve lives, design systems, work for non-profit organizations. The post survey was given during the last week of classes after completion of the design project and was developed to measure the student's changes in perceptions of engineering in part on the basis of the project spectrum (Appendix B). Responses and statements that were evaluated can be seen in the tables to follow.

Survey Data and Analysis: Pre- and Post-Survey Results

The first step taken was a pre- and post-assessment in most sections of the course. Students were given a survey early in the semester (Appendix A) that focused on their perception of engineers in society and familiarity of human service organizations (n=512). The second survey (Appendix B) was given at the end of the course, with similar questions to reveal whether there had been any shift in attitude (n=436). Here are selected results and discussion:

Table 1. Familiarity with the following human services areas, 1=not familiar → 5=very familiar

Human services	Before	After	Statistically significant?
Housing Aid	2.27	2.63	Yes, *p <.001*
Children's Aid	2.42	2.65	Yes, *p <.001*
Medical Aid	2.51	2.83	Yes, *p <.001*
Disaster Relief	2.43	2.96	Yes, *p <.0001*
Hunger Aid	2.47	2.73	Yes, *p <.001*
Environmental Change	2.84	3.24	Yes, *p <.0001*

Table 2. Likert responses to statements about engineering roles. Disagree=1 → Agree=5

Statement	Before	After	Stat. sig?
I believe most engineering work aims to produce products.	3.38	3.39	~
I believe most engineering work improves people's lives.	4.24	4.34	Yes, *p<.01*
I believe non-profit service projects are not (typical) engineering projects.	1.91	2.48	Yes, *p<.0001*
Designing systems to supply a service or aid to people is engineering work.	4.26	4.28	~
Non-profit svc organizations hire engineers as often as for-profit companies.	3.29	3.41	Yes, *p <.007*
Engineering training rarely applies to projects that serve humans in need.	1.84	1.90	~
I think I will be able to apply my engineering skills to help others.	4.44	4.26	Yes, *p<.0001*

These initial results show that while there was some student awareness coming into the course, there was a post-survey increase in knowledge of human services organizations and an increased awareness that they might have a role in non-profit organizations. It appears that our students have a fairly balanced understanding that engineers develop products and serve others in a variety of ways. Anecdotally from years past, if not guided, students would select design projects to create products that helped them as individuals or were familiar to their activities and lives, rarely choosing to focus on societal needs. Some of the results from the last series of questions from the post-survey were quite compelling as shown in Table 3; their perspective and attitude toward future engineering work has changed due to their initial engineering design projects.

Table 3. Likert responses on the class effect on humanitarian awareness. Disagree=1→ Agree=5

Statement	Mean
This class caused me to feel more concerned about social problems.	3.28
I now have a stronger sense of civic responsibility to become involved in my community because of this class project.	3.19
This class has helped me to gain a clearer idea of my professional goals.	3.80
It is likely I will volunteer on a non-profit project in the future because of this class.	3.19

It is notable that the means are above neutral, showing a tendency toward change. This is certainly a positive result, given that the students are not actually working with a service project, and yet they still have a stronger sense of civic responsibility following the first semester and are considering volunteering. Furthermore, the experiences in Engineering Design class seemed to provide students more clarity on professional goals, which as an overall result is propitious for first-year classes. In this first semester at Northeastern University, 40% of the students are often undecided on a major, so some increase in understanding their goals is a desired outcome. Overall, these results are encouraging; the use of humanitarian and service-oriented projects increases the perceived breadth of engineering application areas, and students' knowledge of socially responsible opportunities as well as their potential roles as engineers.

Comparison of Non-Service, Service Oriented, and Service Learning

In a following semester, a service-learning project became available and the project was assigned to one Honors section, and to two teams in each of the two other Non-Honors sections of the design course being taught by the same instructor. A total of 8 teams worked with a community partner in a hands-on project (Experiential Service Learning). Most of the other sections worked on some service- or humanitarian-oriented projects, with some sections having teams involved in general product design. Accordingly, projects were divided into four categories: Experiential Service Learning, Theoretical Service-Learning Humanitarian, Theoretical Service-Learning Environmental and General Design. Definitions used to categorize the projects are as follows:

Table 4: Project Category Definitions

Experiential Service-Learning Project = Actively engaged first-hand in end-user interaction
Theoretical Service-Learning Humanitarian = Possesses societal benefits, is people-oriented
Theoretical Service-Learning Environmental = Improves environment, sustainability
General Design Project = Product, device or system design, not necessarily service

The following graphs show the comparisons of the four project types on the survey questions which are shown as the plot titles. The survey was the same as that given before at the end of the semester (Appendix B), n=392.

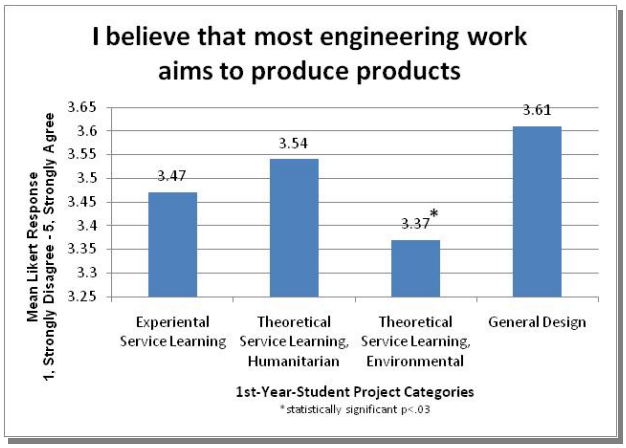

Figure 1: Survey Question 14

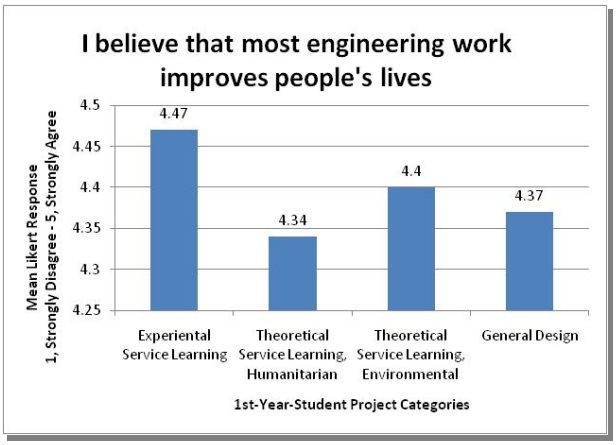

Figure 2: Survey Question 15

On the first two questions shown in Figures 1 and 2, even with limited statistical significance, a pattern emerges showing the effect of the service-based and humanitarian projects in opening up student awareness that engineering work improves people's lives, and is not limited to creating products. The range of the numbers on the second graph is higher, indicating that the students do have a sense that the focus of engineering is to serve people, possibly due to it being a theme of the course and textbook.

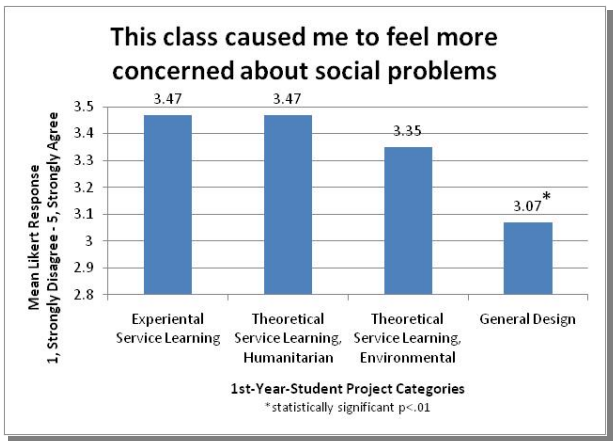

Figure 3: Survey Question 16

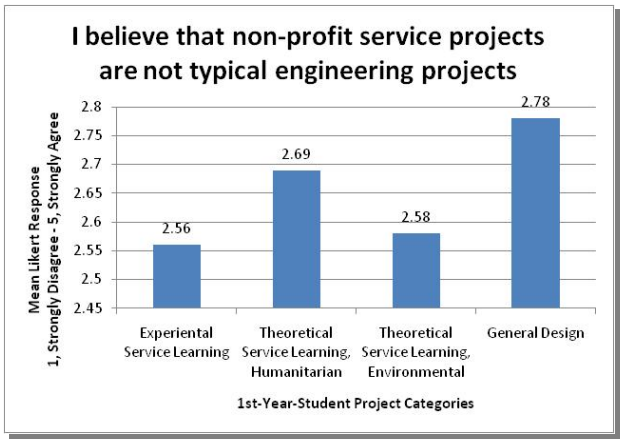

Figure 4: Survey Question 17

Comparing Figures 3 and 4 above shows that students involved in projects that are not focused on service –the general design projects– complete the class with different profiles. They are reportedly significantly less affected in terms of concern for social problems, and demonstrate a stronger sense that non-profit organizations are not the venue for engineering work.

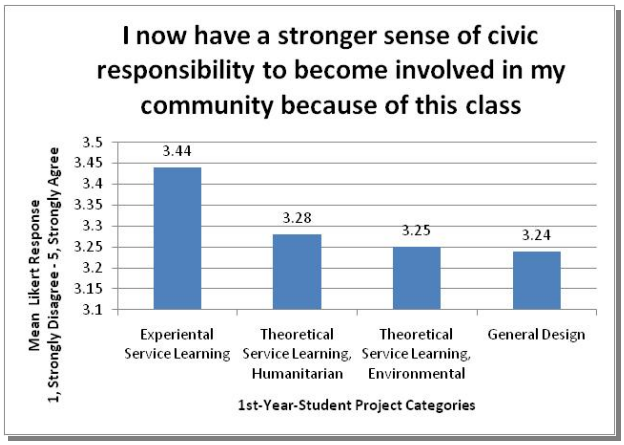

Figure 5: Survey Question 18

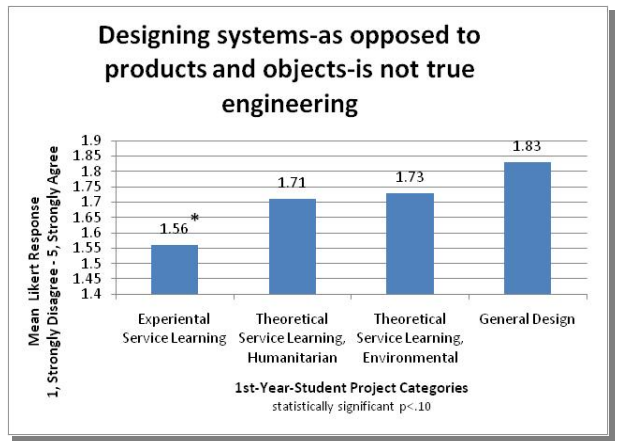

Figure 6: Survey Question 19

Experiential service learning provides some expected and hoped-for results, as shown in Figures 5 and 6. A stronger sense of civic responsibility, though not statistically significant, still appears to be a trend. A shift away from primarily designing products and objects appears to be a result. Many of the students in the Experiential Service-Learning group selected this project over theoretical projects, and may already have had a sense of this coming into the class. Also notable is that the General Design students end up having the highest level of agreement on this question.

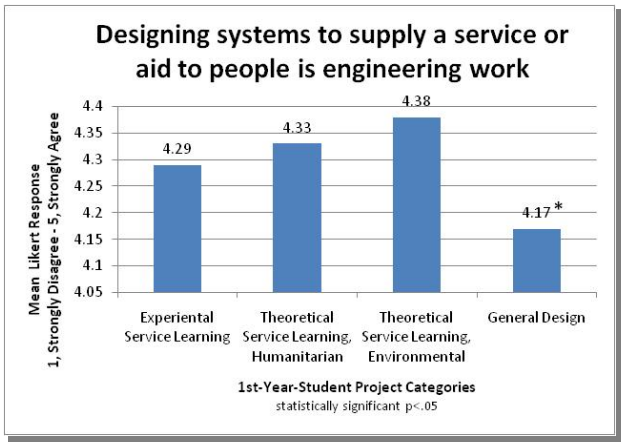

Figure 7: Survey Question 20

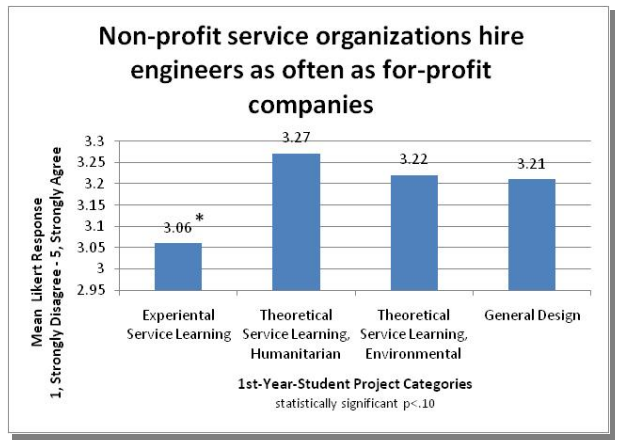

Figure 8: Survey Question 21

Figure 7 reveals that students involved in service projects of any sort hold a significantly stronger view that supplying service or aid to people is truly engineering work. Interestingly, the students involved in the Environmental projects have the highest value. This is possibly due to environmental projects generally being clearer engineering projects, such as alternate power and fuel, or water conservation projects. Figure 8 is a bit of a mystery, after working with a non-profit, it appears that students do not agree as strongly that they will be hired by these companies. A thought here is that the first-hand experience with the community partners revealed to our young engineers the degree to which funds to pay engineering salaries may be

limited for service initiatives. They may actually have a sense that engineers are *needed* at non-profit organizations, but not currently employed by them, an interesting result.

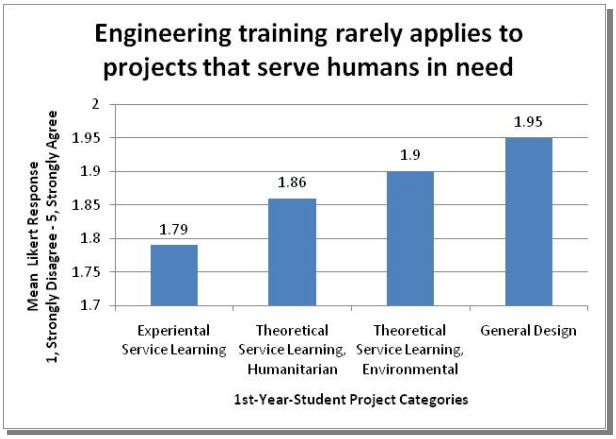

Figure 9: Survey Question 22

Figure 10: Survey Question 23

In Figure 9, a trend is shown in which students who were more closely aligned with service projects and service learning have a stronger sense that engineering training will serve humans in need, although all groups show that they have come away from the course knowing this to be true. In Figure 10, students that selected environmental projects have gained a clearer idea of their professional goals. Note that in the previous section, the pre- and post results showed that greater clarity of professional aspirations is a significant outcome of the course for all students, but appears to be more distinct for the environmentally focused groups. It seems that working on these projects has cemented or fomented where they are heading.

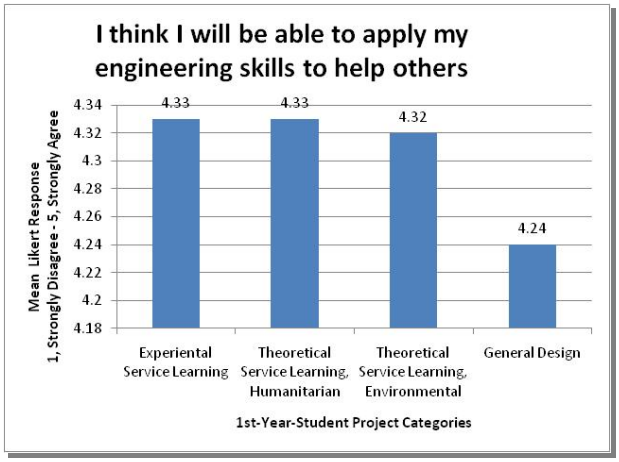

Figure 11: Survey Question 24

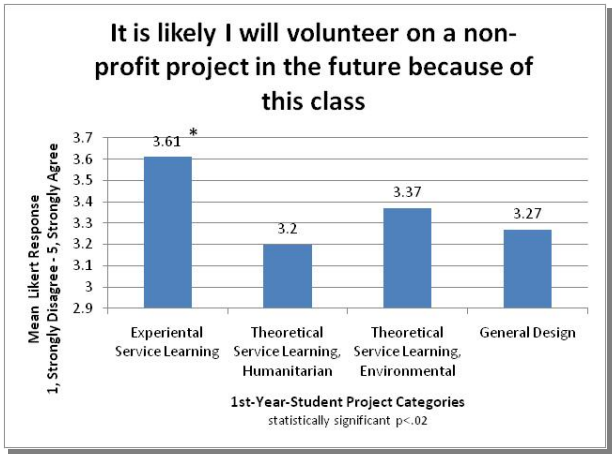

Figure 12: Survey Question 25

Figure 11 indicates that all students agree fairly strongly that they will be applying their engineering skills to help others, but the response levels of the three service-focused groups are higher than those of the general design group. Figure 12 illustrates that experiential service-

learners are significantly more likely to put this in action and be involved in non-profit projects as a result of the class.

In total, what does this set of questions from the surveys suggest? They indicate that the format of the engineering class raises awareness that engineers work to help humanity. All students see every project presentation in class, so even if they were not involved in an experiential service project, they were likely to see students discuss a project that involved them in a direct way, and this presentation, or their own project has an effect on them. The effect seems stronger on the students involved in service-oriented projects of any type versus the general traditional design projects. However, this also may reflect a combination of the effects of the projects and the course itself. It is understood that there are always confounding variables, such as instructor, past experiences with community service, current service involvement and personal value systems. But the cohort is large enough that these factors would randomize across the groups shown in sufficient amounts so as to not taint the results.

Honors vs. Non-Honors and Gender. Other variables analyzed were students with Honors vs. Non-Honors designations, and male vs. female students. Here are relevant results on selected questions shown in the plot title.

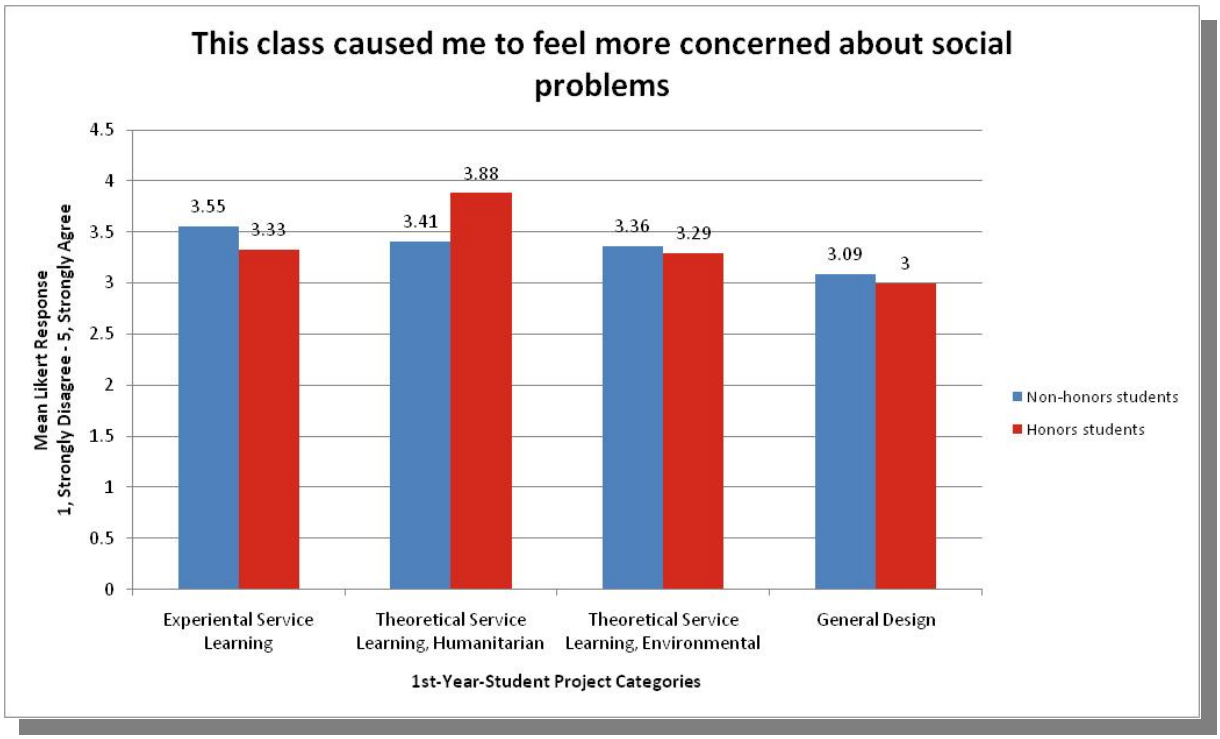

Figure 13: Survey question 16: Honors vs. Non-Honors

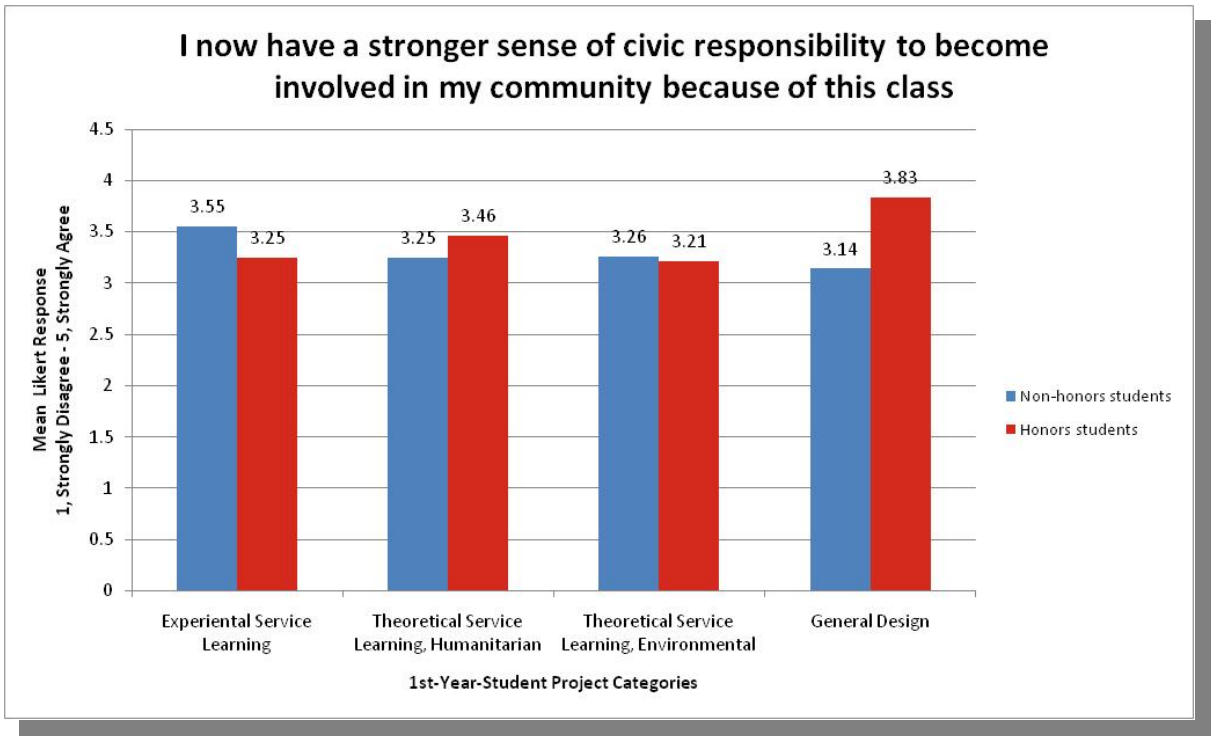

Figure 14: Survey question 18: Honors vs. Non-Honors

In Figures 13 and 14, the Honors students were not significantly different from the Non-Honors students. It is a bit unexpected that the General Design projects seem to have resulted in having a stronger effect on the Honors students, but note that the question is about the class, not the project, so it may be that there was more receptiveness by the Honors students to the service message and information than the Non-Honors. It is hard to discern from the data and results why that might be. Honors students tend to be more involved in community service projects during high school and as part of the Honors program, and may now see engineering tie into that.

Not shown in the figures is that fact that female students have significantly higher values for both of the above questions. This is supported by the engineering and non-engineering literature which reports that female students have a stronger desire to be involved in service learning.[9] In the current study, proportionally higher female students than male students chose the experiential service-learning project, so that the involvement in that project had a high percentage of female students (~40%).

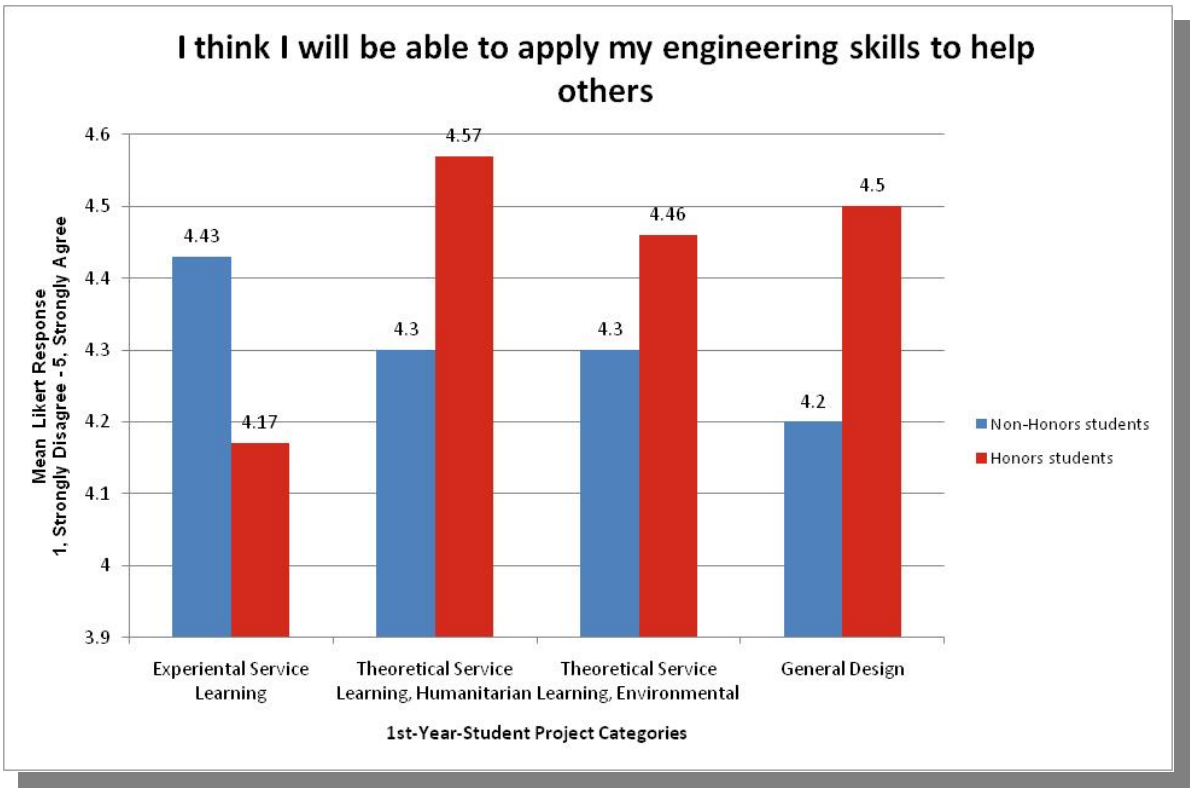

Figure 15: Survey question 24: Honors vs. Non-Honors

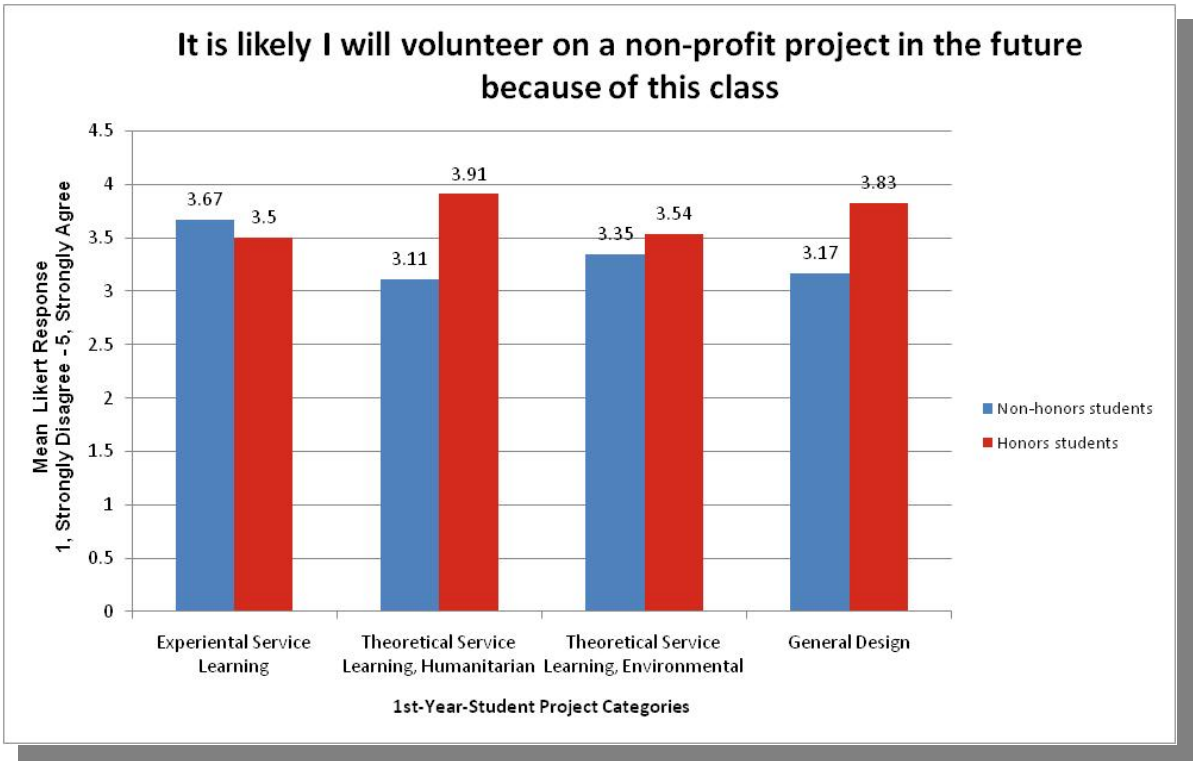

Figure 16: Survey question 25: Honors vs. Non-Honors

In Figures 15 and 16, the Honors students are significantly different from the Non-Honors students, with the highest differences in the non-experiential service projects and general design projects. It may be that again, receptiveness to the concepts and application of service and humanitarian work by Honors students is higher coming into the program, but there is not a certainty that it applied to engineering projects in any way. As a result of the class and possibly their own or other projects, the Honors students are now more strongly inclined to volunteer than their Non-Honors cohorts. Follow-up and other questions might be needed to drill down enough to find the reasons for this.

The female vs. male picture is also strong on the last two questions which address the future likelihood of using their engineering skills for service and volunteering for service initiatives. Women believe they will use their engineering education and competencies to help others and are more likely to volunteer as a result of the class. As shown earlier, all participating students have indicated the class has changed or affected their attitudes toward socially conscious engineering in some way, but the effect is significantly stronger in some groups.

Overall, the service-based inclination of our Engineering Design class seems to affect all participants, particularly those involved in service- or humanitarian-oriented projects. Furthermore, the theoretical service projects and the class focus seem to create a changed viewpoint for all students, not just those that have selected and participated in experiential service-learning projects.

Discussion of Results and Future Curriculum Development

Given our findings, now how might we apply them? At Northeastern University, we plan to continue pursuing coordinating and facilitating experiential service-learning projects. Having those available to students was very rewarding to all involved, namely, the community partners, the students, and the students in the class who saw the details of the hands-on service project and results. In addition, not all students want to –nor are all of them ready– to be involved in hands-on projects with community partners. Students who are very interested in the environment were very excited by their research and designs, and reported gaining a stronger sense of professional goals as a result. This is also an extremely positive outcome.

Moreover, students working on theoretical service learning gained much of the same personal and inspirational results as the experiential students, without faculty having the added responsibilities and potential pitfalls. A combination of project types and allowing students to select those that fit them best at this time in their career appears to be a very positive approach for all. The Associate Director of Northeastern Universities Center of Community Service and the Service-Learning Course Coordinator discussed this research. Her extensive experience in Service learning initiatives echoed our results and observations:

"We have found project-based [theoretical] service learning to still be extremely effective and in some cases preferable to direct [experiential] service learning. For students who may become future project managers and consultants, these provide great experience in planning many aspects of an initiative that they won't necessarily be implementing first-hand."

In many discussions, the *Northeastern University* Community Service representative has encouraged instructors to continue both service-based avenues in their educational efforts. Both hands-on experiences and theoretical service projects are significantly effective in showing first-year students the wide-reaching impact of their skills, their innovation abilities in design, and their potential to make a difference in the lives of others.

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APPENDIX A

Engineering in Society
(A Survey)

1) What is your gender?

Female Male

2) How familiar are you with local current events?

Uninformed.....Very Informed
1 2 3 4 5

3)How familiar are you with world-wide current events?

Uninformed.....Very Informed
1 2 3 4 5

What is your source of current events information?

4 a) Newspaper _____%
5 b) Television _____%
6 c) Internet _____%
7 d) TV News Shows (Dateline, etc) _____%
8 e) Journals _____%
9 f) Magazines _____%
10 g) Other People _____%

What engineering major are you thinking about pursuing? (please check mark)

11 Civil _____
12 Mechanical _____
13 Industrial _____
14 Electrical _____
15 Computer _____
16 Other: _____(fill-in name of major)

17 Have you ever participated/worked for an organization that provides a non-profit service?

Yes No

18 Have you ever participated/worked in a company/business (for profit)?

Yes No

How familiar are you with the following project/work areas that provide human-needs services?

	Not familiar at all 1	A Little 2	Some 3	Quite a bit 4	Very familiar 5
19 Housing Aid	1	2	3	4	5
20 Children's Aid	1	2	3	4	5
21 Medical Aid	1	2	3	4	5
22 Disaster Relief	1	2	3	4	5
23 Hunger Aid	1	2	3	4	5
24 Environmental Change	1	2	3	4	5

25 I believe most engineering work aims to produce products.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

26 I believe most engineering work improves people's lives.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

27 I believe non-profit service projects are not engineering projects.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

28 Engineers can work in product design or system design.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

29 Designing systems to supply a service or aid to people is engineering work.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

30 Non-profit service organizations hire engineers as often as for-profit companies.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

31 Engineering training rarely applies to projects that serve humans in need.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

32 I think I will be able to apply my engineering skills to help others.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

In your own words and opinion, what does an engineer do?

_____

_____

_____

APPENDIX B

Engineering in Society
(end of semester follow-up)

1 What is your gender? Female Male

What engineering major are you thinking about pursuing? (please check mark)

2 Civil _____ 5 Electrical _____
3 Mechanical _____ 6 Computer _____
4 Industrial _____ 7 Other: _____(fill-in name of major)

How familiar are you with the following projects that provide human-needs services?

	Not familiar at all	A Little	Some	Quite a bit	Very familiar
	1	2	3	4	5
8 Housing Aid	1	2	3	4	5
9 Children's Aid	1	2	3	4	5
10 Medical Aid	1	2	3	4	5
11 Disaster Relief	1	2	3	4	5
12 Hunger Aid	1	2	3	4	5
13 Environmental Change	1	2	3	4	5

14 I believe that most engineering work aims to produce products.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

15 I believe that most engineering work improves people's lives.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

16 This class caused me to feel more concerned about social problems.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

17 I believe that non-profit service projects are not typical engineering projects.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

18 I now have a stronger sense of civic responsibility to become involved in my community because of this class project.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

19 Designing systems –as opposed to products and objects- is not true engineering.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

20 Designing systems to supply a service or aid to people is engineering work.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

Engineering in Society
(end of semester follow-up)

21 Non-profit service organizations hire engineers as often as for-profit companies.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

22 Engineering training rarely applies to projects that serve humans in need.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

23 This class has helped me to gain a clearer idea of my professional goals.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

24 I think I will be able to apply my engineering skills to help others.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

25 It is likely I will volunteer on a non-profit project in the future because of this class.

Strongly Disagree	Disagree	Neither Agree/Disagree	Agree	Strongly Agree
1	2	3	4	5

APPENDIX C:

Humanitarian & Service-Based Engineering Major Design Project Ideas – Fall 2010

Global Problems including Lack of Resources or Natural Disasters

(1) Alternative cooking methods for food

Everyday activities that are simple for us in the US are not so accessible in many countries. One example is cooking. There may not be a stove, so that simple wood fires are used for cooking. This may result in over-foresting in many areas, or there may be a lack of firewood already in that area. Which means that the use of cooking fires is not advisable, or possible. The problem is to come up with a means for cooking in a home that does not use wood. Remember that traditional stoves such as electric or gas are not workable in these areas.

(2) Hot water heating system that uses recycled materials and installed in stages.

The Problem: In 2003, 52.3% of the population in Bogotá, Colombia lived below the poverty level due to population displacement from small, rural towns to urban areas. This displacement of population was primarily due to violence and people seeking to better their lives through improved jobs and educational opportunities. Government projections forecast a deficit of 500,000 housing units in Bogotá by the year 2010. To solve the housing shortage, Bogotá's authorities are building new housing providing the minimum requirements for quality of life. Unfortunately, many builders think that families only need space where poor people can sleep. Electric and hydraulic minimum specifications for the social interests housing are very poor. The lack of water heaters is a common denominator; electric power capacity in most of the cases is reduced to 3 KW, and water services for kitchen and bath include only cold-water connections with no provisions for the future improvement of hot water. When a family decides to install an electric water heater, they need to begin by increasing their power capacity. Then they need to install new conduit pipes for wires, new distribution board, and circuit breakers. The actual electric water heater cost around US $600. This is about four months of the family income. In the case of a gas water heater, the heater is more expensive, costing the equivalent of six months of income, in addition to the costs for the hydraulic installation. The cost of solar water heater systems available in the open market is around US $1,750. It is almost three times the cost of an electrical system and doubled the cost of the gas system.

Design a hot water heating system to meet the needs of a small family that uses recycled materials and can be installed in stages to offset the financial burden.

(3) Preventing Disease Transmission

The Problem: Recently, the Swine Flu and H1N1 Virus along with other communicable diseases have caused much of the world to be concerned about disease transmission. The problem is how to prevent the passing of viruses between people, both children and adults. The task is to *design a device or system that stops the virus from transferring, or kills the virus in a concerned area*. This could mean several designs, one for prevention of passing the virus, another for receiving the virus, and then larger devices that reduce or eliminate the virus in public areas, or high risk areas (schools, airplanes, hospitals).

(4) Is the World Overpopulated?

The huge growth in the world population, almost exponential since the early 1900s until now is an interesting engineering problem to deal with. For the period of 1960-2000, the world population increased by just over 3 billion (doubled). This is an average increase of 75 million per year, or about 205,000 per day, 8,500 per hour, or 140 per minute. Because births outnumber deaths, the world's population is expected to reach about 9 billion by the year 2040. As the number of people increases, environmental impact is also expected to increase. Although human welfare and living conditions are improving in a number of countries, it is not sufficient to accommodate the increasing bulk of the world's population. The earth is a finite system with limited resources; as an example the limited resource of land and water required for agriculture, energy, and other needs. Your task as engineers is to make the earth a better place for all to live. Pick a special situation (a country, continent, ..etc) with an alarming increase in population, and design engineering solutions to deal with the situation and to provide sufficient basic needs to the increasing population.

(5) Transformer Shelters for Homeless

The Problem: Ideally, we would like to prevent and solve problem we see around us in the US or in countries where people have been left in need of shelter as a result of political unrest, economic circumstances, or natural disasters. In the meantime, we may be able to help alleviate the immediate problem of itinerant people being without shelter. The solution needs to be comfortable, transportable and affordable. Consider an added feature of making it able to be refurbished and re-used somehow after a period of use or after fulfilling its initial objective.

Choose either: Homeless Shelter for colder/urban settings , mobile for city use, single occupancy, or #8 Homeless shelter for refugees (occupancy 2-4) for refugees/families in rugged hot environment in which they may be traveling over rugged terrain.

Devise a form of portable affordable shelter that could travel with a person if they had no vehicle and a few belongings. These should be able to be mass-produced and easily set up and disassembled without tools

(6) Mobile Units for Different Disaster Types

The Problem: The Red Cross and other disaster relief corps need efficient and modular mobile disaster stations each requiring treatment kits and supplies such as kettles, cups, and water, plus beverage carriers and food transporters. These stations should be able to be adjusted for the type of emergency at hand (fire, flood, bombing, etc.) so that standard supplies are readily available yet unnecessary supplies are not transported needlessly.

Design a mobile disaster station to accommodate the above features. Consider that once you design and propose <u>one</u>, many others would potentially be created after your model.

Energy Conservations and Generation

(7) Electricity Monitoring and Conservation System

The Problem: High electricity bills plague homeowners, but it is difficult to know what the major contributors are to the usage (other than the obvious items such as air conditioners). Also appliances that are in need of replacement, overhaul, adjustment or maintenance often create an excess energy draw.

Design a system & interface to help economize by knowing & monitoring electrical demands.

(8) Self Sustaining Private Energy Generation

The Problem: Energy costs are rising and continue to rise, particularly for homeowners and individuals. There are wind turbines proposed on a large scale, and smaller ones used on boats, but generally not seen in use in this country. There are also other alternatives beyond oil, gas and electric energy. But these alternatives are not in widespread use for homes or in most buildings. Design affordable energy generation methods, possibly in combination, that would replace the traditional energy sources.

Residential/Housing Problems

(9) Residential composter

The problems are 1) compost gets too heavy and icky to turn (to facilitate aeration) in a standard residential compost bin if it is not turned frequently, 2) a standard residential size compost bin is too small to accept the amount of grass clippings, leaves and organic food waste that a typical family collects in one week, and 3) compost that is ready to remove from the compost bin and apply to gardens is difficult to extract from the fresh clippings, leaves and organic food waste before putting in gardens and on lawns. Design a new compost bin that can solve these problems.

(10) Single family home

This home will provide housing for a growing population. The home will accommodate a family of four people in the northeastern US. The maximum floor area will be 2400 square feet, including stairway(s), and excluding porches and garage(s). Western platform construction, or a variation of it, is required.

Possible Design considerations include, but are not limited to:

- One or two floors
- Flexible design utilizing movable walls and floors
- Green/low technology construction: recycled materials, passive solar heating, and super insulation.
- Circuit mapping diagrams
- Plumbing and ventilation diagrams.

Environmental Concerns or Problems

(11) Charles River Cleanup

The Problem: The Charles River is contaminated and unsuitable (unsafe) for swimming or water sport activities. *Design a system and plan for identifying and reducing the contamination and improving the water quality to safely allow for human activities.*

(12) Trash Disposal and Recycling

The Problem: Trash removal, disposal and recycling in large cities like Boston pose challenges different from those encountered in suburban or rural areas. Namely, large numbers of housing occupants generate huge volumes of materials that need to be collected, removed, and transported to facilities outside the city. Consider methods and incentives for recycling, concentrating on the need for convenience, sanitation, and minimal clutter in a variety of metropolitan housing configurations (i.e. having hundreds of little bins all around apartment complexes or in urban neighborhoods is not desirable). Review the design of equipment used in the collection and removal of rubbish and the current methods and systems used for removing large quantities of undesirable materials and then *propose new equipment or systems to help cope with this problem*.

(13) Method of Managing many Used Bottles at Restaurants

The Problem: Empty bottles aren't being re-used at many restaurants; rather they are collected to be recycled into new glass. This takes up too much space and causes a lot of administrative management. Onsite commercial crushers are too big, noisy, expensive, and dangerous, but home trash compacters are too small. How can this recycling issue be managed? *Design an affordable system to assist this management process.*

(14) Stop buying Bottled Water

Recently, cities, towns and states have been pleading with people to stop buying so much bottled water. The trash and recycling of these bottles has increased to such a degree as to be a serious problem, especially when tap water is so readily available. So the problem has a few facets – if the water is potable, how do we convince people to drink it? If the water quality is questionable, how do we improve or correct that? If the water quality is uncertain somewhere, how do you handle that?

Design a solution to this problem, not necessarily one device, it may be a system and device or devices that are needed.

Urban Problems or Issues

(15) Urban Agriculture

Transportation of perishable food (fruits and vegetables) from growing centers in any country can be very expensive and ultimately bad for the environment. Cities are not considered suitable for growing large amounts of crops, there are mostly small "windowsill gardens". In order to accomplish the sufficient production on the scale necessary, you need to consider space, method, water use and air quality.

Design a means for growing large amounts of fruits and vegetables in an urban environment.

(16) Safe Parks, Green Lights

The Problem: Many parks in Boston need to be lit at night for safety and usage. If they are poorly lit, they may not be considered safe at night, such as the Fens near NU. *Research, propose and design adequate lighting for Boston Parks that is also "green".* This lighting needs to be cost-efficient, but also safe and provides enough luminance. It also must be large enough scale for parks in the area, and consider alternative energy sources.

(17) Affordable Transportation

The Problem: In the current economic climate around the world, many people can no longer afford cars, or any available mode of transportation besides walking. Even in urban areas, public transportation can be costly. In order to have a job, people must be able to get there. Many people use bicycles, but struggle to find one that is affordable, and bicycles are stolen, are not good in bad weather, and hard for some people to ride. The problem is to *design some new transportation device(s) that are extremely inexpensive to manufacture but are effective in providing transportation to work*. With affordable means to get there, more people could find jobs.

(18) Rain Water Collection, Management, and Dispersion System

The Problem: Much rain water is lost though evaporation while it could be used for plants and vegetables during dry spells. There are two different populations with this problem:

Problem 1a. Drought-ridden countries that require water to grow their food supply. The solution for this population should be designed for a small parcel of land and should not use electricity.
Problem 1b. Suburban areas with water shortages and water ban conditions who would like to keep their homes and gardens watered. The solution for this population should utilize land commensurate with the 'average' suburban garden size and again should not use electricity.

Design a water harnessing and conservation system to address the issues for one of these scenarios.

(19) Urban wind electric generators

Opponents to "Wind Farms" in rural settings such as the group opposed to the Cape Cod proposal base their objections on the disruption of windmills on the scenery and the possible environmental intrusion. Cities are, however, potentially just as windy as other rural locations and would see even more objection. Design a device that generates electricity from the wind and that can be mounted on a conventional building roof that would not be rejected by these groups.

(20) Campus battery recycling

The problem: Currently, on campus, there is 1 staffed location (22 Ell Hall) where students can deposit rechargeable and/or alkaline batteries during regular business hours and another location (work order office) open 24/7 in Gainsborough Garage. Neither of these locations is particularly convenient to students living in the dorms and faculty/staff are probably not even aware such a program exists. An improved battery recycling program with better campus-wide accessibility is needed.

Design a convenient system to collect and store recycled batteries (AAA,AA,C,D and 9 volt battery sizes) safely. Concerns include preventing the batteries from shorting out in the collection area (and thereby heating up and causing a fire) and containing any potential leakage within the system.

Problems concerning Handicapped/Disabled/Health problems

(21) Supermarket modifications for handicapped shoppers

The passage of the Americans with Disabilities Act mandates that wheelchair-bound people have full access to public buildings. People in wheelchairs can now fully reach and enter stores such as supermarkets. However, it is still difficult, if not impossible, for a person in a wheelchair to shop at a supermarket, even for a limited number of items. Identify and design modifications to supermarkets that will make them more usable by people in wheelchairs without compromising their use for the majority of people who are able to stand and walk.

(22) A system to enable people requiring minimal medical supervision to remain at home instead of being confined to a care facility

The Problem: Often, the elderly or people with disabilities are forced to enter nursing homes, or assisted living facilities in order to get the medical attention they need. Some people require fairly intensive care, while others might be forced to enter due to restricted mobility, lack of a friend or relative to help with medication or to simply check in at regular intervals. In our aging population, this will increasingly become a problem, and will place huge demands on the existing medical/social infrastructure.

Design a system to perform a function that would enable a person to avoid having to leave their home and enter a care facility. Research will be required to identify situations that can be successfully managed with current technology. It would be desirable to identify similar types of needs, and design a system flexible enough to enable application to more than one specific need.

(23) Cost-Effective Transportation for Handicapped People Across the Country

The Problem: Handicapped individuals do not enjoy the same freedom of commercial travel that most of us experience. For example, it is difficult and in some cases impossible for a handicapped person confined to a wheelchair to travel by plane across the country. Assuming that the person confined to the wheel chair is ~225 lbs and does not have the use of his or her legs, *design a cost-effective method or modifications to any of the modes of intercontinental transportation.*

(24) Wearable Device for Health Monitoring and Alert

The Problem: Many people have chronic health problems and concerns, particularly but not exclusively the elderly. They need to frequently monitor the status of these conditions using a variety of devices. Some examples are heart conditions, high blood pressure, or diabetes. They may also be concerned about environmental conditions such as Carbon Monoxide. They do not want to have these various different pieces of equipment to use that are not portable and they want regular or constant monitoring. There are such devices on the market.

Design a portable device that can monitor some or all of these conditions that is lightweight, wearable and can be easily used and read for monitoring health or environmental concerns.

(25) Weight Shifts During Bed Rest for Para/Quadriplegics or Effectively Immobilized People.

The Problem: People with spinal cord injuries or conditions that prevent them from turning over in bed risk developing a variety of serious medical complications related to both blood flow and pressure sores. They need a method by which a patient/person may have their position adjusted periodically, safely, and as gently as possible while in bed resting or sleeping.

Devise a system to assist a person who has some upper extremity (UE, arm-hand) control in getting shifted and/or turned over while in bed. Assume that they do not have enough strength to turn themselves over, but could operate a simple control device by basic UE movement.

There are some systems that attempt to accomplish this or minimize the related problems; your job is to either improve on them or innovate your own method or system.

(26) Handicap Access

The Problem: The City of Boston claims to be handicap accessible, but in many places the access that is provided is arduous to navigate or functionally slow. *Design options for a handicap access system that is cost-effective, efficient and in any other way improves the current handicap access situation*. Consider offering solutions for older buildings, such as the MBTA, Fenway Park or parts of NU Campus.

(27) Transferring Disabled or Saving Beached-Stranded Marine Life

The Problem: When a person or large animal is unable to move of their own accord, assistance from others is required. Humans are made primarily from 3rd class levers and therefore we are not strength machines; we do not have mechanical advantage to produce large amounts of force. As such, a device or mechanism is required to generate power to overcome the inertia and friction of the weight of another body. To follow are two similar problems addressing this topic, each with its own unique challenges. *Devise a portable and relatively lightweight mechanism or system to efficiently, feasibly, and safely accomplish either of the following (choose only one):*

Problem 27a: Help a disabled person (~ 180 lb) get in and out of a car from/to a wheelchair easily. State whether your design will be for an individual to do independently or whether it will be used with the assistance of another person.

Problem 27b: Assist a small group of (5-6) people in helping a beached dolphin, porpoise, or whale back into the water (~400 lb).

The transfer devices for the disabled and the marine life have the criteria that they must be able to be transported by an individual or a handful of individuals, respectively. They should be easily accessed, deployed, and stored in order to be useful. Safety and minimizing costs should also be a consideration.

<u>Problems concerning Children and Child Care and Safety</u>

(28) Safe street-crossing method for children walking to school

As local town budgets become more strained, services such as bus transportation for schoolchildren who live close to school is being reduced. The same lack of money is also making it harder to provide crossing guards at major intersections to stop traffic and allow children to cross safely as they then have to walk to school. Design a cost-effective system that parents will accept for safely having children cross streets with no crossing guards required.

(29) Safe Walking for Groups of Very Young Children

The Problem: When a day care provider or teacher is responsible for many young children at one time, the task of keeping track of them on off site trips becomes overwhelming. It can be nearly impossible for a person to oversee the safety and transport (on foot) of 6-8 young children at once. One or both of the following scenarios requires you to design a device and/or system to facilitate these group adventures beyond the classroom or day care center allowing the charge adult to prevent tragedies by keeping track or containing of all of his/her assigned children.

City Schools/Day Care Centers: walking or transporting young children to the park or playground (within) walking distance of the permanent site.

Kindergartens or Day Care Enters: Walking to/from buses and on sites of unfamiliar places – could be city or country, but any device or system used must be portable.

(30) Child Protection System

Every year, children are kidnapped, sometimes with tragic results. Usually, these kidnappings are crimes of opportunity that occur because parents or caregivers cannot watch over children in their care all the time, and because the children's disappearances are not noted immediately. Design a way to ensure that children cannot be missed.

(31) Individual Entertainment System for Hospitalized Children

The Problem: Many young patients stricken with childhood diseases must remain in isolation with little social contact amongst their peers and have no access to entertainment during this difficult time. The patients are required to spend many days in the hospital undergoing treatment. This project is to *design a system that will furnish not only entertainment and educational stimulus for individual patients, but also will provide the essential social interactions that may help young patients stay connected to others as they recover*.

(32) Child Front Seat Safety Measures

In automobiles, many states do not require a children's booster seat for passengers older than 5 years old or grater than 60 lbs, although pediatricians and other safety experts recommend minimums of 9 years of age and 90 lbs. Your groups' task is *to design a means to protect a child who sits in the front seat of an automobile*. The design should accommodate a young child (or a small adult) who is greater than 5 years of age and weighs more that 60 lbs.

<u>Other Problems</u>

(33) Clean and Green Restroom Routine

The Problem: Many public restrooms are adopting an even more health-conscious approach for their users to avoid contact-related diseases infections, and germs. This involves equipment and fixtures that facilitate clean routines in the lavatory areas. Practices to this effect involve water flow, soap dispensing, hand-washing, hand drying, disposing of paper towels or tissues (in some cases), and contacting surfaces in the facility. *Considering the ergonomics, movement of people, sanitation, customized and special needs, design a facility and its fixtures to address all these needs.* While many parts exist to solve these problems, think about the smoothest flow and least amount of inconvenience, dripping, waste, mess, and contamination to generate a state-of-the art system to be installed that takes the facility

engineering to a new level and considers the effectiveness and efficiency of the task, within a realistic budget. Your mission is delimited to the washing areas for a restroom that has 8 sinks in a space of about 80 Square feet with provisions for 2 ADA-compliant width doorways. (ADA – Americans with Disabilities Act)

(34) Portis Family House Playground Design

A small house in the Boston Area houses 7 families that have been reunited during recovery of a parent from drug or alcohol abuse. In the yard of the housing area they have a small playground that is unsafe and needs to be redesigned. The area is small and sloped with existing cement walkways, plus a number of existing obstructions and challenges. It is also used for cookouts, outdoor meetings and gatherings. There is a very small budget for the project.

Problem Statement: Design a playground/outdoor play area for Portis house families. The users will be children ages 1-18. Pictures and dimensions of the existing area provided.

(35) Device for Preventing Voice Damage

Teachers, public speakers, singers, and other people who use their voices extensively and for a living often damage their voices and vocal cords over time and if not managed carefully. This occurs for many reasons, but one is speaking louder than necessary. Many times a speaker is using too much volume for the room. Other problems are pitch, quality of tone, where the voice is being produced and amount of breath being used. When vocal cords are damaged or being damaged, they also lose a smoothness of sound, that rough, scratchy forced sound replaces a smooth tone. A speaker could benefit from a wearable device that provides feedback about the current state of the voice; volume, tone, pitch, other – to help them change their vocal use before more damage occurs.

Design a (possibly wearable) device that provides a voice professional (speaker, teacher, singer) with feedback on vocal quality to prevent vocal cord damage.

(36) Engineered Methods to Expand Capabilities of Service Dogs

The Problem: Service Dogs are trained to assist disabled individuals in order to help make them more independent in their homes and in society. These loving and intelligent creatures are trained extensively and have succeeded in serving as valuable attendants to their human companions. Many are able to open doors, retrieve items, and carry out a variety of other tasks such as leading their companions to the nearest empty seat, alerting their companions in urgent situations, etc.

Conduct in-depth associated research to propose, design, and develop a <u>variety</u> of <u>engineered</u> devices and adaptations that expand the capabilities of service dogs in terms enhancing the quality of life for their human companions in conducting activities of daily living inside and outside the home.