Industrial Engineering Students Making a Difference - Capstone Design Projects Impacting Adults with Disabilities

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Abstract

This work in progress describes the results, direct impact, and experiences of senior Industrial Engineering (IE) students who ventured in an IE Capstone Design Experience, funded by NSF, to "Make a Difference to Benefit Adults with Disabilities". This particular experience required pairs of senior students to interact with a multidisciplinary team to develop, build, and implement prototypes to foster independence and self-care, improve the safety and quality of life of individuals with disabilities, and augment their functional capabilities. The results of five capstone projects and the student learning outcomes are described from a program assessment perspective, along with evidence of how these experiences create awareness, sensibility, and knowledge on the needs of adults with disabilities while broadening students' appreciation of the impact IEs can have in society and wellbeing of others. The impact of developed prototypes on the users is shared as part of documenting the success of the implementation.

Keywords

Capstone design project, adults with disabilities, design prototypes

Introduction

IE Capstone projects provide a meaningful design experience for senior students, through a guided opportunity to apply knowledge and experiences gained throughout their undergraduate experience. This work in progress describes the project results and the direct impact and experiences of senior IE students who ventured in an IE Capstone Design Experience, funded by NSF, to "Make a Difference to Benefit Adults with Disabilities"[1]. This particular capstone design experience required teams of two senior students to interact with a multidisciplinary team of health professionals, clients, and engineers. Many of the student teams included senior undergraduate students from other engineering disciplines. Their focus was to develop, build, and implement prototypes to foster independence and self-care, improve the safety and quality of life of individuals with disabilities and augment their functional capabilities[2]. These projects differ from traditional IE capstone projects that focus on industry problems.

The projects completed during the first two years of the project target the population of adults with disabilities and resulted in the design of: 1) an ergonomic tool for people with upper limb prosthesis; 2) a gait trainer; 3) a therapeutic cross-body movement and sensorial therapy system; 4) a sensory stimulation equipment; and 5) an ergonomic grip for a kitchen knife. Details about the projects, blueprints and results are available at the project webpage[3].

Assessment Results

Learning Outcomes are goals that describe how a student will be different because of a learning experience[4]; with particular emphasis on knowledge, skills, attitudes, and habits of mind that stem from the learning experience. Our program assessment is based on Student Learning Outcomes as defined for the ABET A-K Engineering Assessment Criteria[5]. Six key learning outcomes are aligned with our Capstone course, including the ability or understanding to: (1) design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability (Outcome C); (2) function on multidisciplinary teams (Outcome D); (3) identify, formulate, and solve engineering problems (Outcome E); (4) understanding of professional and ethical responsibility (Outcome F); (5) communicate effectively (Outcome G); and (6) use the techniques, skills, and modern engineering tools necessary for engineering practice (Outcome K).

As part of the program assessment activities, students self-assessed their confidence in applying several skills aligned with specific learning outcomes. Results of skill mastery for all students enrolled in the course (N=88) during a two-year period, show that for five of the learning outcomes (Outcomes D, E, F, G, and K), at least 92% of students could perform activities with minimal guidance, as well as work independently or innovate.

A Two-Sample t-Test, assuming Unequal Variances resulted in no difference in the mean level of confidence between students who participated in the project and students completing traditional industry projects. The learning outcome regarding the ability to "design a system, components, or process to meet desired needs with multiple constraints" (Outcome C) showed significant differences in responses between groups. Participants in our project showed higher self-assessment mean scores when compared with the general group, although this was the learning outcome that showed need for strengthening in other students, as 8% of students in traditional projects stated they could not perform the task or needed substantial guidance.

As part of the course, industry supervisors evaluated the execution of the project teams on different criteria using a five point Likert Scale (5-Very Strong to 1-Very Weak). In some projects, particular criteria did not apply or supervisors indicated they were unable to judge the particular aspect. Key areas where industry supervisors provided higher evaluations ($\mp$0.50 mean differences[*]) in NSF Projects versus traditional projects were the following: Global impact of proposed recommendations to address areas of opportunity (Outcome C, +1.45) and attainment of project objectives (Outcome C, +0.58). It is important to highlight that in student self-evaluations, those who were part of the NSF Project rated themselves higher with respect to ability to design than students in traditional projects. On the other hand, those criteria where industry supervisors had lower evaluations in NSF Projects versus traditional projects were related to the "Quality of the economic analysis of recommendations" (Outcome K, -0.61). Overall, compared to the first year of the proposal, the NSF projects during the second year were stronger in design although weaker in analysis and impact. Results for other outcomes (D, E, F, and G) did not show important differences in final student evaluations.

[*] Mean differences refer to a standard statistic that measures the absolute difference between the mean value in two groups.

Student-self assessment reflections provided a means to document evidence of impact of the design experience (refer to Self-Assessment Tool in appendix). Students described that they gained and reinforced knowledge in a variety of areas including: ergonomics and safety, sensory stimulation, electrical systems, cost analysis, automation, information literacy, patents, and engineering mechanics. Relevant skills developed or strengthened include: the importance of interdisciplinary and multidisciplinary teams (i.e. engineers and therapists), design methodologies and product development, as well as written communication, research skills, and project management.

Assertions captured from student reflections in the assessment process provide evidence of the impact in awareness, sensibility, empathy, and knowledge on the needs of adults with disabilities as well as a broad appreciation of the impact IEs can have in society and wellbeing of others. In the project exit survey, students shared: *"The biggest reward is to know that the quality of life of human beings is going to be improved"; "I was able to design something which the population greatly needs (while I) applied my IE knowledge"; "...from now on, besides working for a company, I want to dedicate myself to helping others"; "I am aware … I can use my knowledge (to) help others too; people who don't have the resources to be independent"; "I've grown as a person… put myself in someone else's shoes"; "this is a perfect example of how our focus on the people can have a positive impact on society. (If) the main focus is always on the human factors ... any project will always consider the impact on people and keep the wellbeing of others as its core".*

Impact on Users

As an example of the project impact, we have gathered feedback from the users who received the prototypes as part of the project. The user with upper limb prosthesis who has the Ergonomic Tool designed in the capstone course shared that "*the device really works"* and that it has helped him on his *"daily activities because changing bulls was one of the few things that I could not do by myself"*. The user who has the Ergonomic Grip for a Kitchen Knife shared that "*the product has been great so far. It has given me independence and now I don't need help cutting the food. (My caretaker) can now focus on other things while I eat… and her time is better used. The only thing that prevented me to eat alone was not being able to cut the food. This has been a huge emotional change in me. I now feel like I can do more independent stuff … I have a great motivation to try it. The therapist told me that it was good to exercise."*

Future Work

Currently, there are six additional projects in progress as part of this effort that will be completed by June 2017. Assessment and evaluation activities to measure the impact of the project on students and users will continue to be used to monitor project achievement of outcomes.

Appendix

Reflection Questions: The following questions are designed to help us understand the personal and professional impact of a capstone project focused on benefiting adults with disabilities. All questions relate to your experiences in the capstone project.

1. How do you feel about the experience of completing your Industrial Engineering Capstone Design to Benefit Adults with Disabilities?
2. What influence can Industrial Engineers have to impact society and the wellbeing of others?
3. Do you believe this project has made an impact in your personal and professional life? Explain how.
4. Identify 3 new things that you learned through this project.
5. Identify 3 things/ideas/knowledge that you reinforced through this project.
6. Identify several skills that you gained or refined as part of the project.
7. What helped you to succeed in your project?
8. Looking back, what things do you think would have helped you to do a better job in the project? Think about the curriculum, knowledge, skills and resources.
9. What is the value to you of what you learned from the process and the project?
10. Reflecting upon your experience, what can you share with future students about the process and the project that could help them to succeed?

Self-Assessment: Please identify your level of agreement with each of the statements provided below using the following criteria: Completely Agree/Agree/Neutral/Disagree/Completely Disagree.

1. This project helped me develop technical and professional skills to practice the IE profession.
2. The group work in this project helped me develop interdisciplinary teamwork skills.
3. The oral reports and presentations helped me develop oral communications skills.
4. The written reports helped me develop written communications skills.
5. This project allowed me to take into consideration energy related issues as part of the design process.
6. This project allowed me to take into consideration ethical issues as part of the design process.
7. This project allowed me to take into consideration legal issues as part of the design process.
8. This project allowed me to take into consideration societal issues as part of the design process.
9. This real-life project experience was a successful complement to the ININ educational process.
10. This project was much more difficult than other capstone projects.
11. This project allowed me to integrate the principles, methods, and techniques of earlier course work into a real-world problem solving situation.

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