

Projects for People with Disabilities in a Capstone BME Design Class

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Abstract: This paper describes components of a capstone engineering design course in which students develop custom assistive devices for people with disabilities. Typical engineering curricula do not expose students to rehabilitation engineering or important issues related to working with people with disabilities. To help students have a successful experience in our class, we organize lectures, discussions, student presentations, and other activities and assignments that give an overview of rehabilitation engineering disability concepts. Student feedback indicates that this has been useful, and that their project experiences have been rewarding.

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Introduction

The biomedical engineering departments at Duke and UNC each offer capstone design courses in which students design, fabricate and deliver custom assistive devices. Each device is built for an individual in the local community who has a disability. Student teams work closely with the client, their family, and local health care providers to develop a device that meets the client's needs. At the end of the semester, the students deliver their completed device to the client. Examples of past projects include a custom modified trike for a boy with congenital limb deficiencies (Figure 1) and a special rock climbing prosthesis (Figure 2).



Figure 1: Custom Trike Modification

Rehabilitation Engineering and Disability Topics

To design a device that meets the needs of the client, the students need to understand the design process, and how it is applied to the needs of people with disabilities. As seniors, the students have the necessary technical background, however, before taking our class, many have little or no exposure to working with people with disabilities. In order to prepare them to succeed, we have developed a specific set of experiential learning activities to expose students to important concepts in rehabilitation engineering the needs of people with disabilities.



Figure 2: Climbing Prosthesis

We organize a number of lectures and discussions (sometimes facilitated by a guest lecturer), student presentations, and other activities and assignments that expose students to relevant issues in rehabilitation engineering. These include the following:

- Panel on interacting with people with disabilities: This helps to prepare students for their first meeting with their client. Topics include: potential effects of a disability on the client's functional abilities including communication, mobility, education, social, etc.; using "people first" language; and the roles of the family, teacher/supervisor, and health care professionals who work with the clients.
- Disability awareness exercises: Students participate in a set of structured activities that have the goal of gaining some understanding of different disabilities such as physical, cognitive, visual, sensory and speech disability. It is important to note that these exercises are intended to teach about disability in a very general way and help students develop understanding and awareness of different disabling conditions.
- Living with a disability: An individual with a disability talks about their experiences and perspective.

- Rehabilitation Engineering and Universal Design: An overview of the field of Rehabilitation Engineering, including case studies, and a discussion and demonstration of Universal Design concepts.
- Field trip. The class has a field trip to a local agency that works with assistive technology for people with disabilities. This provides an opportunity for students to speak with clinicians and try out a variety of commercial products.

Each team does several presentations during the semester: a project proposal/design review within the first month, a progress report in the middle of the semester, and a final presentation at the end of the semester. The presentations provide students with valuable experience in giving formal presentations, and they provide an opportunity for students to get feedback on their project design.

To address the latter issue, local health care providers, teachers, and advocates who work with people with disabilities are invited to the presentations. Most of them have little technical background but extensive experience with people with disabilities. As a result, they provide a valuable real-world perspective on the students' designs.

The students consult with a team of people who know the client well, shown pictorially in Figure 3. Students visit the client at least 3-4 times during the semester to develop their design and try out their prototype. In between visits, students communicate with the client and support team via phone and email.



Figure 3: Students working with client and clinician

Engineering Design Topics

Students are also exposed to engineering topics commonly found in accredited engineering programs, such as:

- Ethics in engineering: A facilitated discussion about ethical issues in the fields of engineering, health care, and disability. Students find, review, present and discuss articles that pose an ethical issue.
- Design process: Presentation of an iterative design process. This is review for most of our students.
- Designing to standards: Students are required to evaluate their design with respect to existing standards.
- Fabrication and machine shop safety: Common mechanical and electrical processes used in the fabrication of medical devices. Additionally students are required to complete machine shop safety training before using university equipment.
- Safety analysis: Students prepare a hazard analysis on their device. They list the potential hazards that could occur during use. For each hazard, they determine whether they should modify their design to eliminate it, or provide warnings to the users.
- Device functional and user satisfaction evaluation: Each team is required to evaluate the performance of the device with respect to the design criteria. Additionally each device is evaluated for user satisfaction.

Discussion

Through the lectures, presentations, and activities described here, students receive training which helps to prepare them to work with clients with disabilities. We feel that this has been successful according to a number of measures. Feedback from clients, their families, and their health care providers indicates that in most cases, the student projects have met the needs of their clients.

In addition, several students have gone on to graduate school in the field of rehabilitation engineering, indicating that this class influenced their career choices. Finally, feedback from students indicates that they benefit from the course experience and feel rewarded by using their engineering skills to help a person with a disability.

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