Engineering Innovation: First-Year Student Reflections Convey Impact of Externally Sponsored Assistive Device Design Projects

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ABSTRACT

Introduction. The University of Dayton's first year Engineering Innovation course was introduced in Fall 2008 as a 'cornerstone' design course where students solve real-world needs using the engineering design and innovation process. Research suggests that providing students real-world and meaningful projects as early as the first-year of college improves retention and subsequent course motivation.[1,2] Though students begin the semester with a more traditional 'introduction to engineering' activity (i.e. "design a cardboard table"), the majority of the semester is devoted to the real-world project, largely structured after the University of Dayton's capstone design courses. Each course instructor is tasked with identifying an appropriate project, and a relevant "client", for his/her section of 24 – 28 first-year engineering students. Though the course has been largely successful, an important distinction must be made between the role of the client in the senior capstone courses and the role of the "client" in the first-year cornerstone course. In the senior capstone courses, projects are externally sponsored by industries and community partners paying to have teams of students synthesize the knowledge garnered over their college years with the expectation that over the course of the yearlong capstone a solution to a fairly narrow problem will be realized. In the one-semester, 2-credit, cornerstone course, ideation, innovation, and design process are emphasized and due to lack of prior knowledge, budget, and time, promising ideas and often usable, though rough prototypes, emerge - but not at the level expected by clients for the senior projects. For this reason, traditionally the Engineering Innovation cornerstone course will select community partners from the local area who present broad needs to the class, with the understanding that they will get usable ideas and design concepts, but not necessarily ready-to-implement solutions.

In Spring 2012, Dr. Kim Bigelow's Engineering Innovation course section became the first section to be externally funded through a research contract with Kettering Health Network aimed as designing assistive devices for patients at the Kettering Health Network NeuroRehab and Balance Center. It is the objective of this presentation to detail the lessons learned from this external sponsorship of a first-year class so that others might replicate it, while also evaluating the impact the experience had on students as conveyed through written reflection.

Methodology. This presentation summarizes the experience of Dr. Kim Bigelow's Fall 2012 Engineering Innovation course section, the second semester of the partnership with Kettering Health Network. The Fall 2012 course was an all-female course section, as compared to the Spring 2012 traditional mixed-gendered section. Rationale for an all-female course has been described elsewhere.[3] The twenty-four female engineering students in the course were broken up into six teams of four students. For Fall 2012, Dr. Bigelow worked with the clients to budget $10,000 for the project (inclusive of indirect costs). This included a budget for every team to have $150 to use in prototyping, and a set aside fund to move the most promising devices further

in subsequent semesters, by more senior students. Dr. Bigelow also worked with the client to generate a problem statement that was broad enough that it allowed each of the six teams to go in different directions, while also scoping it so that functional solutions could be realized within the time, budget, and skill set of the students. The problem statement, introduced by occupational therapists from the NeuroRehab and Balance Center, was kept very broad, challenging students to design assistive devices to help individuals who have partial paralysis due to stroke do various kitchen tasks. The therapists provided examples of challenges that individuals faced, but did not propose specific solutions. Students worked to define specific aspects of the problem they would like to solve, generated design alternatives, performed decision analysis, and participated in a formal Conceptual Design Review with the clients. After designs had been refined according to feedback received during the Conceptual Design Review, students completed a functional prototype and developed and carried out tests of feasibility. Ultimate deliverables included the prototype, a final presentation to the clients, and a final written report for the clients. Additionally, students completed a self and peer evaluation and a written reflection summarizing their experience. These reflections were read and comments relating to the specific project and the clients were identified. These comments were then grouped into common themes that emerged and summarized to determine the impact of the experience on the students.

Results. Six fairly distinct prototypes were delivered to the client at the conclusion of the course. One of the prototypes, addressing the difficulty individuals have reaching things toward the back of refrigerator shelves, was ready to be used "as is" (though would require some modification for mass market). Two other prototypes did not function properly due to difficulties building and assembling, but the ideas were similar, and promising, enough that the client felt they could easily be integrated and taken further. A fourth prototype was very innovative, but required a very strong magnetic field, which could not be generated with the materials purchased. Additionally safety concerns over the use of magnetic fields with individuals with pacemakers cautioned refinement of the design. The clients were still excited about the concept and kept it to be possibly revisited at a later date. The remaining two concepts were acceptable ideas but at this point were not compelling enough to take further, largely due to similarities to other products on the market. Though not all of the projects were "successful", the clients were ecstatic.

From the student perspective, several trends emerged. One of the most common themes was that students had gone into engineering because they wanted to help someone, and that they were thrilled that they had a chance to "make a difference" as early as their first year. Related to this, some of the students conveyed that this experience helped confirm and motivate them for careers in engineering. Another theme that emerged related to the externally sponsored nature of the project was the excitement knowing that the projects had the possibility of being implemented to help "real" people. For example, one student wrote, "Working with this client was my favorite experience as well as the most impactful. It made me happy to know, even if my design was not chosen, that patients would be able to have a device that would help them while working in the kitchen." This also led students to suggest that they worked harder "to ensure that we would not let them down." Many of the students also commented on how "honored" they were to have a sponsor, as this meant they had belief and confidence in the students' abilities. Per the logisitics, a few interesting reflections comments were made. For example, several students said they were upset that the clients had not been more direct and forthcoming with criticism and felt the instructor sometimes played the "middle man" in delivering this news. Another student

commented on the project's success largely coming from the open-endedness of the project that allowed each student team to go in a different direction. Another student conveyed that she was not overly excited to work with the client because she didn't know anything about neurological impairment, but that the project showed her that working with things she is not familiar with actually leads to more innovative ideas.

Discussion. Nearly all students agreed that the project was meaningful to them and that the presence of an external sponsor motivated them to work harder. They also felt that because of the sponsorship, their ideas would truly be considered as possibilities that could be realized to help people. In previous semesters when the client was not invested in this manner, students had not conveyed this – suggesting a strong impact of having a sponsor. However, in having an external sponsor, there are some specific strategies that help make the most of the experience. First is to convey expectations of course deliverables, and when possible, share examples of past prototypes with the sponsor. During the first semester, the clients expected prototypes to be more refined and market ready. By the second semester, the clients better understood what to expect and therefore also agreed to budget money to take the most promising ideas further. Having a pathway to advance ideas is important, and is also motivating to the first-year students to know that they ideas they began will be tackled by upperclassmen. Two other critical pieces to the project's success are 1) scoping of the problem to be broad and achievable with simple solutions, and 2) the conceptual design review where feedback can be given to get students "back on track" and best aligned with the client's needs. However, based on student reflection comments, it is most useful when the conceptual design review feedback is critical and honest.

Challenges with a project like this include constraints of time and student skill set. One of the more challenging components is interweaving rigorous analysis, or even prototype testing into the design. Depending on the product testing required, the most desirable tests may require Institution Review Board (IRB) human subject testing approval, which may have too long of a turnaround to be feasible within the semester. A validated evaluation tool for assistive devices is in existence; however depends more on subject perception over technical engineering aspects.[4] It should also be noted that the project will appeal to some students more than others. The project was much more warmly received in the all-female course over the traditional course, though most students in the mixed gendered course were still very engaged. It was thought that this would be a meaningful, real-world project for students.

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