Engineering and Nursing Collaboration Yields Significant Social Impact and Marketable Product Designs
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ABSTRACT
Collaborative design between the engineering and nursing disciplines is beginning to make a very significant social impact. This article describes a number of student designed products that have had a direct social impact on a small number of disabled individuals. Social impact is also evidenced by students expressing transformational awareness as they design products for the underserved in society. Broad impact is being made as the program draws public attention, including news articles and acknowledgment in a recent speech by First Lady Michelle Obama. The authors contend that there is potential for very broad social impact by commercializing the products designed by students, but the path to commercialization is very challenging, especially for a primarily undergraduate program. The authors describe failures, lessons learned, and plans for establishing a product commercialization process within the undergraduate program. The commercialization process itself will require a collaborative effort to attract participants from any or all UDM colleges.

Introduction
The mission of the University of Detroit Mercy (UDM) emphasizes the social development of students. The college of Engineering & Science and the college of Health Professions deliver a collaborative capstone design course motivated by this mission. The course, which includes active participation by engineering and nursing students, was described in a paper and presentation at the NCIIA conference in San Francisco (McClelland and Kleinke 2012). With the complementary expertise of engineering and nursing working together, capstone design projects are aimed at helping the disabled community and, in doing so, offer rich social impact for all participants. This paper describes the types of products developed and how those products have both immediate social impact and the potential for much broader social impact on society.

After four years of operating the collaborative course, a successful track record has been established for developing custom-designed devices for use by individuals with disabilities. Although the first prototypes are custom built devices, the product concepts have the potential for commercialization on a broader scale. The types of products are as varied as the types of disabilities that have been addressed as part of the course. Through the collaboration process, the nursing faculty has identified clients with unique, unmet needs. Devices have been custom-designed, prototyped by the students, and delivered to the clients for use (Kleinke and Rayess 2009). Several specific product examples and their related social impact will be described in the beginning of this article, followed by the overview of a plan for expanding that impact through design commercialization.
Social Impact on a Personal Level

Unique Devices Aid Disabled Individuals

The direct impact on a single individual is the narrowest social impact, but that does not diminish the importance of that impact. In addition, the end product is a device that has the potential to help many others with similar disabilities. In fact, the potential for the product to have broader impact has been a selling point for client participation. As nursing faculty interview potential client participants, they explain that client participation may lead to devices that could help many other people. This has proven to attract willing clients who are primarily interested in helping others. In turn, the cooperative attitudes of the clients have contributed to the development of the types of products described below.

Some products designed by students are relatively simple devices, yet the products have significant social impact. UDM has worked with the Michigan Department of Labor and Economic Growth, which has the mission of finding employment and providing accommodations for people who are capable of working if they can overcome their limitations. The story of an injured Detroit police officer was included in an international publication. In this case, he was unable to use his right hand, and had lost his job as a mail clerk. The students designed a gripping device that allowed the client to grasp items (McClelland and Kleinke 2011). The gripping device consists of a spring loaded clamp that fits into an exercise glove. It is a relatively simple device which is inexpensive to create, fits a wide variety of sizes, and has the potential to help many people. This simple kind of product idea represents an opportunity for students to explore entrepreneurship and product development without necessitating major investment.

The most typical outcome of these student projects is a product of mid-level sophistication. The product designed for a Detroit public school teacher was an example that also has the potential for commercialization and greater social impact. In this case, the client was paraplegic and was about to take delivery of his first vehicle outfitted with driver's hand controls. His request was to have students come up with a method to help him build upper body strength so he could transfer himself from his wheelchair into the driver's seat of his new vehicle. The students designed an exercise device that allowed the client to strengthen his upper body while still using his power wheelchair. Before delivering the device to the client, it was demonstrated at the Detroit assistive technologies expo, where it drew purchase inquiries from several show attendees, indicating a potential broader market for the product. Figure 1 shows students delivering the upper body exerciser to the disabled client. This type of passive exercise device is quite basic from an engineering perspective, but requires a significant amount of refinement and adjustment to be user-friendly.
The most sophisticated designs were motor-driven devices for an office worker who was disabled following muscular attacks due to multiple sclerosis (MS). His request to the students was to help him learn to walk again while he was in remission periods. The nursing students helped the engineering students understand the aggressive nature of MS and the rapid pace of muscle atrophy. With this knowledge, the student teams prioritized their efforts and designed two active-assistance exercise devices to help the client learn to walk again after an MS attack. The first device rotated the client’s ankle and knee joints to promote circulation while the client slowly regained muscle tone. The second device rotated the client’s hip joints, which also promoted blood circulation while the client recovered. Figure 2 shows the students helping the client take the ankle and knee device for a test run. These devices are more sophisticated, as they include drive motors, controllers, and sensors. Development and refinement of these devices would be costly and require significant development time and greater investment.
projects have had set-backs. In some instances, the clients become unavailable during the course of the project. In two separate cases, the clients moved out of the geographic area during the time period of the course and were no longer eligible for services from the sponsor organization. The students were distressed and disappointed by these developments. However, the unforeseen circumstances became teachable moments as the students had to grapple with project objectives that needed to be re-set midway through the work. In one case, the students quickly adopted a new client (the Detroit public school teacher described above). In the other case, the students had to change customer-specific requirements and redesign for a broader clientele. Unexpected changes in projects are not uncommon in industry. Learning to be engineering nimble is an important outcome.

**Products Designed for the Disabled Demonstrate the Impact on Student Perspectives**

The student-designed products reinforce the social consciences of the students. The student team that worked on the hands-free stroller pusher is an example. Their product is designed for parents and grandparents with upper body disorders. The product attaches to a standard stroller and permits the user to control the stroller by physically connecting and disconnecting with a magnetic latching device. The students demonstrated their understanding of the needs of the clients and produced documented interviews with potential customers in a YouTube video, which can be accessed at: http://www.youtube.com/watch?v=1TIDhWUsE&feature=g-user-u. Figure 3 shows a photograph of the device being demonstrated by one of the student-designers.

In another product design team, the students worked interactively with students from the College of Health Professions to learn the fundamentals of basic human functions, which in turn helped them design a product. In this case, the client had been involved in a tragic fire four decades before the students met him (Henning and Reddy 2010). His injuries severely limited the dexterity of his arms and hands. Consequently, the client had not been able to inde-
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independently use utensils to eat soups or cereal from a bowl for decades. The students designed a special eating utensil that made it possible for him to eat soup independently without any expensive equipment. In this case, the students learned to not take everyday abilities, like eating, for granted. They also understood that there are many more people that could benefit from their work. Consequently, following completion of the course, the students applied for a provisional United States patent (USPTO application #61692350). The inventors include engineers and nurses. They entered the Accelerate Michigan business competition, applied for an E-Team grant, and continue to develop the product. Figure 4 shows a photograph of the product.

Figure 4. The spill-proof eating utensil

Failures sometime occur, as projects don’t always turn out as planned or desired by the students and instructors. In a recent case, the students approached the instructor with a request to leave the prototype unfinished at the end of the course. However, that would have prevented them from delivering a working product to the client. The students did not want to disappoint the client, and they put their minds (and hands) back to the work, developing and delivering a working prototype. The end result was that the students learned a lesson in social responsibility.

Social Impact on a Broad Scale

Raising Society’s Awareness of the Needs of the Disabled

The work of students designing products for the disabled community helps raise social awareness. The UDM program has made headlines, which helps keep the needs of the disabled in the public eye. Several recent news stories have highlighted the needs of the disabled and have shown how students can make a difference! Examples are cited in the following paragraphs.

During the spring of 2012, a news piece was published in the online edition of the Detroit News (DetNews 2012, archived). The article highlighted UDM’s work on the spill-proof spoon described earlier in this paper and described how nurses and engineers work together to address the need of our clients. The news piece caught the attention of a local organization, and subsequently UDM was invited to participate at the Henry Ford Museum’s Maker Faire.

In July 2012, the UDM-sponsored booth at the Henry Ford Maker Faire provided the opportunity to demonstrate how engineers and nurses can help the disabled community. The Faire was attended by a diverse audience ranging from retirees to grade school children. In many cases, people attending the Faire stopped at the UDM display, identified themselves as nurses, occupational therapists, or physical therapists, and proceed to describe a client that would benefit from one of the devices on display. The display helped nurses see how engineering could be beneficial to their field, and it helped
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the technically inclined visitors see how their skills could be used to help the disabled. The “Capstone Project - Engineering and Nursing University of Detroit Mercy” video is available on YouTube: http://www.youtube.com/watch?v=Nfj8KtypqtY. The video is now used regularly during recruiting visits to attract students to the Science Technology Engineering and Math (STEM) disciplines.

The broadest impact was realized when the program received national recognition in a recent speech by First Lady Michelle Obama. The UDM program was mentioned directly:

But we know that training exists. We know that information is out there. We know that high quality of care is possible, and we see examples every day, all across this country. At the University of Detroit Mercy School of Nursing, nursing students are working with engineering students to design devices that will help veterans with disabilities return to the activities they love. And they recently worked with a veteran who had trouble grasping objects and holding his arms steady. With the device they built for him, he’s been able to resume his favorite hobbies -- hunting and photography. And that’s so important. Nurses were right there (The White House 2012).

Broad impact activities are not immune to failures. As students prepare for demonstrations to the public, they encounter challenges. Each project must be demonstration-ready, which can be difficult. One example of failure occurred during preparation for the Henry Ford Museum Maker Faire. The students needed to have their wheelchair-pushing device ready to demonstrate. Unfortunately, the students decided to make a slight design change the night before the demonstration. The change was ill-conceived, as it made the device inoperable. Last minute corrections saved the day, and the device operated properly at the show. Ultimately, another problem occurred and the drive system eventually gave way, disabling the demonstration. Fortunately, the final failure occurred very late on the last day of the Faire.

Plans for Social Impact on a Very Broad Scale

Commercializing Student Products for the Disabled

By developing a process to commercialize student designs, we can reach many more people hampered by disabilities, but the road to commercialization is very difficult. Some of the major challenges involve organizational issues, curriculum fit, student and faculty involvement, and funding.

Organizational issues hamper the commercialization progress. It is a major challenge to assemble the right mix of expertise and interests, especially during the start-up phase of a commercialization exercise. Typical universities are not geared toward product development and therefore lack the infrastructure, both physical and organizational, to develop a product beyond the concept prototype stage.

Curriculum fit is another issue that hampers design commercialization. The engineering undergraduate curriculum is crowded with technical analysis courses, core curriculum requirements, and very few electives. There is little room to include product development.
Student and faculty involvement is yet another stumbling block to commercialization. During engineering capstone courses, students are very interested in exploring the full potential of their ideas, and student interest may persist for some time following graduation as well. However, the necessities of life, families, and careers eventually push the dream of a new product venture to the lowest priority. Without guaranteed income, students cannot afford to risk a new venture with many unanswered questions. Likewise, faculty members are pressed to deliver research scholarship, teach a full load of courses, and serve the community, leaving little time to explore the potential for new products.

Finally, funding is an issue. In order to secure substantial funding, a well-developed product is desired, but the product cannot get to the well-developed state without funding. As a result, numerous great ideas generated by students are abandoned each year as capstone classes come to a close and final reports are filed away.

The following sections provide an overview of a commercialization plan that strives to overcome these issues and create an avenue for student creativity to reach the disabled community through new products.

Proposed Commercialization Plans
The intention of the commercialization plan is to unleash the potential of undergraduate energy at UDM and then, if successful, to have a broad impact across the country. Another goal is to recruit a diverse population of incoming freshmen into the engineering and nursing professions by showing them how they can have significant social impact. A team of faculty and students at UDM are currently developing a proposal for such a program.

The plan is to create opportunities for students to develop and launch their products as they see fit. The sustainability of the business, the direction of the business, and the business decisions remain the purview of the students. The challenge is to create a program that is educational, yet commercially viable.

The following is an excerpt from a proposal being prepared for UDM administration consideration:

Overview
The goal of the organization is to facilitate and educate students to form student-led business alternatives that will take ideas from concepts to viable and marketable products. The process we aim to implement will be structured under the University mission to assist the community by addressing the needs of disabled clients.

The following excerpt addresses organizational issues. The goal is to provide student-lead business ventures with expert consulting and to provide a stable entity to build investor confidence. For faculty, appointment to the commercialization board would become a recognized position endorsed by the university administration. As such, the faculty can be allotted course release time, develop branches of their own research, or count their board work as service time. An overview of the proposed commercialization board is described below:
Commercialization Board

Overview of the Board’s Make-up and Responsibilities

The Commercialization Board of Directors will be composed of no less than three faculty members representing the colleges of Engineering, Business Administration and Health Professions, appointed by the respective schools. Undergraduate and graduate student representative will be appointed by the student senate. The commercialization board is responsible for soliciting patrons, managing funds, providing guidance to students, and advertising the commercialization opportunities to the university community.

Determine Product Technology Readiness

Product proposals, submitted to the Board by student teams, must be analyzed and assessed to determine if the proposed product is worth pursuing further. In general, there must be some understanding of the market potential, a clearly defined concept, and a foreseeable path to commercialization.

Resources and Revenue Agreements

Once the technology readiness of the product has been approved, intellectual property protection will be determined by the Commercialization Board. Intellectual property ownership and revenue sharing agreements will be negotiated by the Board on behalf of the university and will be in full compliance with university and union policies.

The commercialization board will not place any demands on the existing curriculum. No additional courses, nor modifications to courses, will be required. However, the opportunity for students to develop their ideas into full-fledged products (with the help of the commercialization board) presents new curricular options. For example, if a student happens to develop a creative idea during a freshman engineering course, that product could become the subject of a personal “spiral-curriculum” in which the student progressively develops the idea as he or she learns new analysis methods and techniques.

The authors propose to institute a student chapter of the Collegiate Entrepreneurs Organization (CEO). The students will be offered shares in new products endorsed by the commercialization board. The endorsement includes a promise of some level of seed funding.

The following excerpt describes the role of the CEO chapter in the product development process:

Collegiate Entrepreneurial Organization Chapter

The CEO chapter should fuel entrepreneurial enthusiasm across the university through advertising, special events and word of mouth. Make the general population of university students aware that there are opportunities to develop their ideas and use their talents specifically to help the disabled community.

The CEO chapter will facilitate the formulation of student teams, and pair them with actual products endorsed by the commercialization board. The CEO leaders will develop a process to identify the best mix of talents and right-size the teams to move the product development process from conceptual designs to market-ready products.
The final issue is funding. The existence of the commercialization board is aimed at strengthening the case for external funding from foundations, government agencies, and private investors. With the commercialization board providing stability and expertise, and the CEO chapter providing student-powered enthusiasm, much stronger proposals will be presented to potential grantors and investors.

Conclusions
Collaborative design between engineering and nursing has created significant social impact, as evidenced by the number and variety of products designed for individual recipients. The program is having broader social impact, as evidenced by the number of newsworthy reports and acknowledgment by the First Lady.

There is potential for very broad social impact through commercialization of the designs. The vision for a commercialization process described above addresses organizational issues, competing demands on students’ availability, crowded curricula, and inability to secure funding.

The authors have learned from failures, and have outlined a plan for establishing a commercialization process in concert with the educational program of a primarily undergraduate institution.

References


