# AC 2009-1253: FACES ON DESIGN: A PARTNERSHIP AMONG CLIENTS, STUDENTS, AND COMMUNITY VOLUNTEERS

**Nassif Rayess, University of Detroit, Mercy**

Associate Professor of Mechanical Engineering. He received his BS and PhD degrees in Mechanical Engineering from Wayne State University and joined the University of Detroit Mercy in 2001. He is a member of the team spearheading the development of the Entrepreneurship program at UDM.

**Darrell Kleinke, University of Detroit, Mercy**

Assistant Professor of Mechanical Engineering. He earned his BS and MS degrees in Mechanical Engineering from the University of Michigan, and his PhD in Mechanical Engineering from Wayne State University. He has over 25 years of industrial experience and is a licensed Professional Engineer. He taught as an adjunct faculty at various universities prior to joining the University of Detroit Mercy in 2008.

# Faces on Design: A Partnership between Clients, Students and Community Volunteers


## Abstract

This article describes a useful framework for bringing social entrepreneurship to engineering students. In the proposed framework, members of a team of engineering students are partnered with a disabled person with a particular need and tasked with finding, modifying or creating an assistive technology that would help fulfill that need. At the other end, that same student team is partnered with one or more volunteers from the skilled trade community who will implement their design and create a functional working prototype. In this partnership, faculty members act as gate keepers, ensuring safety and facilitating the interactions between the students and the other two stakeholders. At the center is a legal document that indemnifies all parties by ensuring that the client understands that the device/technology that s/he receives is modified equipment and must be used as instructed and under their responsibility. Although assistive technology development in the context of the senior design course is a fairly common practice in the US, this article describes the business structure and educational framework that allows for this technology to be developed rapidly, built professionally and brought to the client in a fairly short time. This provides the students with a very rich experience on many levels including interfacing with the disabled community, understanding government regulations and guidelines (i.e. FDA, CPSC) and creating a design that is well documented and easy to manufacture. The authors will use a recent venture as a case study and will share initial feedback from all constituents (client, students, faculty and volunteers) as well as initial assessment of the educational experience. A discussion of future plans is also presented.


## Introduction

Service learning has grown in importance to the extent that it is now on the strategic path of most engineering and technology programs in the US. Along with social entrepreneurship, they are well regarded and supported by scholarly journals. They are also supported financially by foundations and government agencies. This particular activity is supported by a Kern Entrepreneurship Education Network (KEEN) grant from the Kern Family Foundation.

This paper describes the relationships between service learning and social entrepreneurship in the context of engineering education. It then presents the anatomy of this particular venture using the latest models of social entrepreneurship research. The educational and pedagogical aspects are then discussed, followed by two projects that serve as case studies. The experience is then briefly evaluated and preliminary assessment is presented. The paper concludes with a discussion on the future plans.

## Service Learning and Social Entrepreneurship

Defined as "a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development"[1], service learning is not only beneficial to the overall

development of the student but also addresses the hard-to-assess qualitative educational outcomes *f* and *h* of ABET[2]. For the sake of completeness, these two educational outcomes are *an understanding of professional and ethical responsibility* and *the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context*.

Service learning is a beneficial educational practice in all fields of study, in particular when it is a part of a professional education program (law, health professions, etc…). The preponderance of free law and health clinics[3,4] that are staffed primarily by students are very telling examples. In their creation, they draw on the paradigm that if one needs to practice his/her profession in the course of professional training, that practice should yield economic and societal benefits, especially to the underprivileged who could not afford such vital services at market rate.

Law and health services, by their very nature (short time frame, limited service-based client-provider relationship, etc…), are well suited for the type of service learning models involving mobile law clinics or inner city health/dental clinics. There is real harmony in such a service based model that does not exist in engineering. The services rendered in an hour by a doctor, for example, could change someone's life. The services of an engineer in that same time frame are of a fairly limited value, especially to the underprivileged. Although, there are few examples of service learning where engineering students seem to provide a valuable service (helping low income household conserve energy[5] is one example), the literature points to the service learning activities being primarily in the realm of product creation and design. These types of transactions are fairly complicated, requiring teamwork, a fairly extended development time frame and manufacturing considerations. The complexity of the undertaking warrants enough planning and organization to bring these endeavors to the level of social entrepreneurship. If the required outcome is to be a product, what is needed is a social entrepreneurship venture to design, manufacture and maintain such product.

**The Social Entrepreneurial Venture**

Social entrepreneurship is characterized by activities that involve the creation of social value rather than commercial value. The academic model to describe entrepreneurship by discussing the interrelationship among the four components (people, context, deal, and opportunity)[6] was extended to the realm of social entrepreneurship[7] and provides a good basis to describe the framework. The four components are presented here but the overall strategy is discussed first in the form of a short "elevator pitch" type of format.

People with disabilities and in particular parents with disabilities require help in carrying on with their lives and to be productive members of society. Technology offers a wide range of good solutions but the one-off nature of many disabilities necessitates a one-off type of solution that does not benefit from market based solutions or even short-run production techniques. There are many models to integrate the education of engineers with the design and prototyping of socially beneficial products and services[8-11]. This enterprise draws upon the experiences of the academic community but goes a step beyond to involve community volunteers who are able to help prototype the student designs. The faculty act in the role of managing partner, by providing

guidance, scheduling and contacts. The faculty also maintains a comprehensive liability release document that is signed by the client prior to the start of any work.

***The People and Resources***

People and resources are the bedrock of any enterprise. In business lexicon, people are often referred to as the *talent* with all the catchphrases associated with that term (attracting talent, retaining talent…). Resources are the capital (financial and otherwise) that is so essential to the proper functioning of any enterprise. This venture is a partnership between a number of stakeholders, all of whom are volunteering their time and effort. This partnership extends to external parties that are providing support and referrals, and thus are a principal resource.

The primary stakeholders are the students. This enterprise was created for their benefit. Thus far, only engineering students have been involved but students from various disciplines (Architecture, Psychology, Health Professions, etc…) will be involved in the near future. The entrepreneurship program at the University of Detroit Mercy (UDM) involves an interdisciplinary design course[12] that will serve as the model. The students could be engaged either in the senior capstone course or in the context of co- and extracurricular activities. Examples of both are presented later in this article. The students are generally very interested in this kind of experience, and even in a small university like UDM, the ability to carry on these types of projects is not limited by the availability or willingness of students.

The client is a person with a special need, generally a form of disability. One of the principal constituencies is that of parents with disabilities. For these people, the joy of impending parenthood gives way to worries about the "mechanics" of baby care, i.e. transportation and handling of the baby. Questions such as how can a mother in a wheel chair get her baby out of a crib or how can a father, disabled due to the loss of use of an arm, buckle his child into a seat belt are a great source of worries. In some unfortunate circumstances, these issues have led to legal and custody problems[13]. Gut wrenching decisions about whether to have or keep the baby are very common. Against that backdrop, a disabled parent is a great partner in this enterprise. They usually are anxiously waiting for the product and would gladly answer any questions from the students.

The instructor/faculty acts as the managing partner of this partnership. The faculty is tasked with advance planning to identify clients and sponsors, establish a rapport, and assure all have reasonable expectations. He/she acts as a gate keeper in order to ensure safety and to guide the design and development process.

In many cases, a third party sponsors the project. The sponsor may provide financial support, volunteer time, refer the client or function as the liaison. The sponsor may be an individual, a government agency, or a non-profit organization. In this case, the clients were referred by a non-profit organization dealing with parents with disabilities issues. Sponsors are typically eager to participate in the projects. The value proposition for them is very attractive. Other than the ideas and design plans, the sponsor gets a custom-built device, for the cost of the materials. The design, development, and fabrication work is free. Sponsors are typically very willing to accept the risks of the program knowing that the possibility exists that a successful and safe device

might not be produced. They realize that there is a possibility that the students may not develop a successful or safe device. It falls to the faculty to pull the plug on this work and convince the client of that fact. Luckily, this has not happened yet but will very likely happen at some point and the authors do not relish the prospect.

The volunteers from the community who are asked to contribute their particular manufacturing skills are principally important stakeholders. These devices will be used in the care of newborns and babies and the students will most likely not have the necessary manufacturing skills. The community volunteers contribute their valuable skills and time without getting compensated and the rationale for that is threefold. This partnership will not have enough funds to operate in the future if manufacturing costs are needed. Furthermore, these devices would be completely unaffordable if they are to be made at market manufacturing rates. Most importantly, the quality of the manufacturing and the attention to details are believed to be better if the partnership remains as what behavioral economists refer to as a social contract[14] vs. the common market contract where services are compensated monetarily. The sense of ownership that is bestowed on the community volunteers is essential because they are needed to spot problems in the design that might not be apparent from the CAD modeling or the FMEA's of the students.

***The Context***

The context in an entrepreneurial venture is the operating environment and other factors that are outside the influence and control of the managements. In cases of social entrepreneurship, the regulatory and tax policies, the economy and competition are the primary external influences. Regulatory agencies set the standards for the safety and efficacy of consumer products and devices, especially those that are designed for use by the disabled community. The tax policy and the economy have great influence on the philanthropic environment and the willingness of foundations to provide funding.

The students are directed to visit the website for the Consumer Product Safety Commission (CPSC)[15] and read up on any of the latest issues and recalls. Even if no actionable information can be gathered by this exercise, it would serve to put the students in the proper frame of mind as they are thinking about design ideas and requirements[16].

This particular endeavor is fairly immune to economic factors as all the work is done on a voluntary basis and the cost of the materials has been shown to be fairly small. Besides, the arrival of a child into this world is a dominant positive emotional experience that compels many people to overlook economic factors that would otherwise dominate their decision making.

***The Deal***

The deal can be summed up by the question *what's in it for everyone involved* and just as important *how is success measured*. All stakeholders benefit from this partnership. The client gets much needed help in the form of a device that is either not available commercially or is too expensive owing to the small size of the market. The university and the faculty benefit by providing a much sought after education framework for their students. Also, this endeavor fits perfectly with the mission statement of the University of Detroit Mercy, providing some

welcome ancillary benefits to the careers of the responsible faculty. The students get to work on meaningful projects that excite the sizable portion of the mechanical engineering students who are glad to be involved in something that has no wheels for a change, as one student put it. Also, the faculty supervising the students work will make sure that publicity or a publication/ presentation result from this activity that will help the student. The benefits to the sponsor are obvious since, as an entity, they exist to provide these types of services. The benefits to the community volunteers are deeply rooted in the philanthropic spirit of this country.

The second question of assessment is easy to understand but difficult to implement as anyone who has ever written a grant proposal can attest. Unlike commercial entrepreneurship ventures that are generally assessed by financial statements, social entrepreneurship endeavors are hard to assess because the benefits are hard to quantify mathematically. However, in this case, one measure is the number of people who received a device that helped them carry on through their disability, how happy they were with the function provided and would they recommend such a device to someone. The number of students and their feedback is also a good measure.

### *The Opportunity*

The opportunity in this case is not a growing market, a technological breakthrough or a disruptive innovation. It is a fairly well understood need by a small, yet significant, portion of the population for devices that help in caring for children (particularly babies) or carry on in their work despite the onset of degenerative diseases and such. There are many state and federal agencies that are particularly interested in the latter[17]. In reality, there is no shortage for opportunities to do this kind of work.

## The Educational Context

This endeavor was undertaken primarily for the educational benefits of the engineering student. Thus, it should be described in that context. The experience is very valuable from the student's perspective. Beyond the great motivating experience of working on a meaningful project (a project with a face, thus the title *Faces on Design*), the students benefit in a number of ways starting from the first stages of design to the last stages of testing and validation. The students benefit by having a willing client's help in setting the design criteria and specifications as they are creating a Quality Function Deployment (QFD). Also, one of the hardest design tasks for students is to get them to work on a meaningful Failure Modes and Effects Analysis (FMEA). A common phrase that many faculty teaching design hear from students is this *needs to work for a couple of weeks*. When a deserving person is expecting and needs the prototype that the students are designing, they are apt to spend some time and energy to ensure that it lasts and is safe.

Also, students tend to start building before their design is finished and documented. When a third party is going to manufacture their design, this tendency is curbed significantly. The same goes for finishing their work early to leave time for testing and validation. In one case, a baby was sleeping in a baby seat for two months while waiting for the wheelchair accessible crib to be finished. The students, working on an extracurricular basis, had no choice but to get the work done and to get it done right.

## Case Studies

The two projects discussed here concern the creation of assistive technologies to aid parents with disabilities in caring for their children. Disabled care givers have serious misgivings about the "mechanics" of baby care, i.e. transportation and handling of the baby. For them, there are very few assistive technologies available that one can buy. The small size of the market coupled with an expensive operating legal environment limits the existence of commercially available technologies. Yet, the need is very real and is central to gut-wrenching decisions of whether to have or keep the baby.

The first project concerns the creation of a baby seat attachment to a power wheelchair and the second involves modifying a crib to make it wheelchair accessible. The baby seat wheelchair attachment was done as a project for the mechanical engineering two semester senior prototype design course. It involved a team of three students. The wheelchair accessible crib was done strictly on an extracurricular basis. In either case, the framework discussed here supported this work equally well. Both projects were completed successfully and used by the respective parents to the great benefit of the baby and the parental relationship.

### *Power Wheelchair Child Carrier Attachment*

The baby seat attachment was a design solution for the problem encountered by a mother with cerebral palsy. With one baby, she was able to use her lap for transportation and was able to provide her baby with what seems to be a great childhood. With a second baby on the way, she felt that she needed a mechanism to seat both babies safely and securely as she travels around in the day when her husband is at work. The team created an attachment that held a child bicycle seat, which they termed the CARE: Chair. Figures 1 shows the design as well as the actual prototype in use. That chair was used for over a year until the older child was able to walk around safely. The team "tested the waters" of creating a business around such a technology and pursued funding though an Advanced E-Team grant from the National Collegiate Inventors and Innovators Alliance (NCIIA). They also considered filing for a patent. At the end, the business fundamentals were clearly pointing to a dead end. Regardless, that design was documented and two prototypes were constructed. As the children seen in Figure 1 grew and no longer needed that device, it was retuned and has been refurbished and made available for the next person.

The contribution of the community volunteers was in the welding of the chromium steel alloy used in the construction. Even though the students had access to state of the art welding equipment and the training to use it, they felt that these critical welds are better done by a trained professional. They contacted a welding shop and had a person do it for no charge.

### *Wheelchair Accessible Crib*

The child accessible baby crib project involved modifying a crib to be used by a disabled mother who uses a wheelchair. The prevalent crib design involves a door that slides vertically and drops enough for a standing parent to bend down and pick up the baby. Clearly, that is not feasible for a person in a wheelchair. The modifications shown in Figure 2 included raising the entire crib so that the knees of the person in the wheelchair can get underneath the crib. Also, the door was

made to slide sideways instead of up and down and once it slid halfway, it then could swing open if that was needed. The sliding action allows the parent to control the opening and gradually secure the baby. Provisions were made to ensure that the crib remains a safe environment for the baby, free of pinch points or any other hazard. The students determine that the interface with the baby should remain as close to the commercial object as possible and thus designed the crib to minimize the changes. They chose a common crib and made sure that all the components can be purchased from a home supply store. The design and the bill of materials are available and the work is such that any experienced woodworker can carry it out.

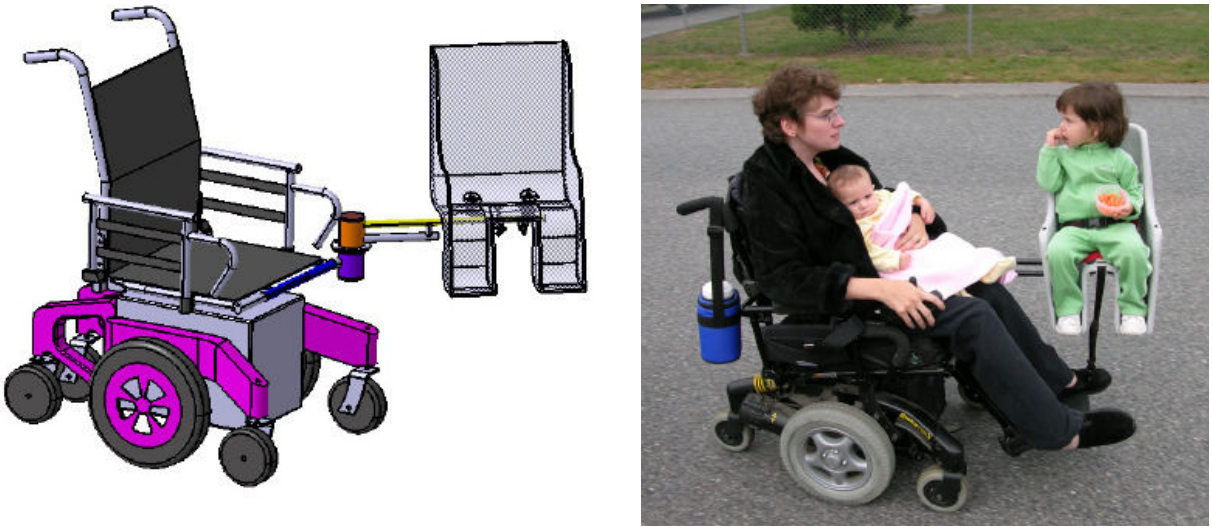

**Figure 1 –** Power wheelchair child carrier (rendered design on left and actual use on the right)

**Figure 2 –**Wheelchair accessible crib (rendered design on left and actual prototype on the right)

## Preliminary Assessment

By every measure, the assessment presented is very preliminary. The reason being is that this endeavor grew in a fairly organic manner and the faculty was taking it one project at a time so to speak. As far as the educational outcomes assessment, these projects were undertaken alongside the regular capstone projects which cover topics such as research and industry sponsored product development. The assessment conducted in the course of ABET preparation is done in an aggregate fashion and anonymously and thus a differentiation is not possible. However, these projects have brought a great deal of benefits nonetheless. The students seem very interested and motivated by these types of projects. An ancillary benefit has been the attractiveness of these projects to the female population. Allowed to select their project in the senior capstone course, the three teams that worked on the wheelchair project in its various stages consisted in total of 6 women and 5 men. Meanwhile, the engineering population at large at UDM consists of 25 to 30% female. This might seem anecdotal, but the authors believe it to be quite striking. As this partnership moves forward and grows, rigorous assessment will be undertaken and published in the future.

## Conclusions

Social entrepreneurship projects offer great opportunities for engineering students to apply their skills in meaningful ways and to acquire excellent and necessary soft skills that will help further their careers. This educational objective is achieved through the creation of a partnership that brings students, clients, faculty and volunteers together to work on enabling technology projects, particularly ones concerning parents with disabilities. Initial assessment shows that all constituencies are well served and even more telling is the forward momentum that is being felt by everyone involved. The partnerships are being expanded with more agencies participating, more faculty members involved, more students and more projects.

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