

Experiential Education and Broad Value Creation is Enabled by the Disabled

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Abstract:

People with disabilities have been actively involved with the mechanical engineering capstone design course and they have made a remarkable impact on engineering education and on value creation.

In terms of engineering education, the client's physical disability presents an obvious design-study opportunity for students, but more importantly, the client-student relationship simulates the customer-engineer relationship. Students learn in a very personal way that the value of a product is ultimately determined by the customer, not by the design engineer. Opportunities for teachable-moments are enabled by the involvement of the disabled.

In terms of value creation, if the student team is successful in meeting the individual needs of the client, the resulting product then has the potential to be commercialized and valued by many people with similar disabilities. The course requires students to create immediate value in the form of a working prototype delivered to the participating client, but the students are also required to design for much broader value to society through commercialization of their product.

Opportunities for actual products and real entrepreneurship are enabled by designing for the disabled.

Introduction

The theme of the North Central conference is "Value Creation through Engineering Education." The author suggests that persons with disabilities can be valuable assets for the educational experience and they can be wonderful assessors of value.

The author has gained considerable experience with persons with disabilities in the context of mechanical engineering design. In this context, the individual with a disability participates as a real live "client" for student design projects.

The author had extensive prior experience with more traditional subject matter, such as design competitions and industry sponsored projects. The clients with disabilities have added a dimension to the design course that is so impactful, that the entire program has been dedicated to addressing the unmet needs of the disabled.

Engineering Education – Enabled by the Disabled

Perhaps the greatest advantage of incorporating clients that are disabled into the design class is reflected in student comments: “it makes the work matter.” The clients make the course work personal and meaningful for the students¹. The assigned grade becomes secondary as the students strive to satisfy their clients, rather than achieve a letter grade.

Before describing example experiences and teachable moments, the author feels compelled to add a bit of commentary. At the beginning of this program, it was the author’s naive concern that there might be a shortage of suitable projects and subject matter related to disabilities. The unfortunate reality is this; there is an astonishing number of people with disabilities for which there are unmet needs, which could be addressed by the most fundamental of engineering solutions. Perhaps on a global scale this begs an engineering ethics debate, but for educators, the paradox is that this represents a vast quantity of engineering projects that can be executed on a level commensurate with undergraduate engineering student capabilities.

Experiences involving clients with disabilities

Persons with disabilities have made significant contributions to the engineering education experience, for both the students and the instructors². The following section describes three examples of their contributions and how they have reinforced important engineering lessons. A suggested template for selecting and managing the client involvement is provided following the examples.

Example 1: Mr. Delbert McCoy* - Burn injured client

* For this example, the client’s name and injuries are provided as they are a matter of public record. Mr. McCoy has published his personal story in a book titled, “*Still on Fire*,”³ which is an inspirational read.

In the early phase of each project, a major education experience occurs as the students are required to interview their client to determine how they might apply their engineering skills to resolve an unmet need for the client. No a-priori suggestions are given to the students. Rather, they are advised as to how to respectfully interact with their client and they are encouraged to not just listen, but also observe the client’s circumstances and environment. Since the client is dealing with a disability, it is very unlikely that anyone on the student team can presume to know the unmet needs. Some useful heuristics⁴ have resulted from these experiences:

The lesson: The engineering designer needs to understand the customer’s needs.

Aside note: Typically, in these meetings, the client will “tell the story” of how they became disabled and what their life is like. Without variation, the students are amazed at the clients’ courage, determination and spirit.

Teachable moment – The initial client meeting with Mr. McCoy was also attended by his friend, who was assisting Mr. McCoy by pushing the wheel chair on the day of the meeting. The students directed all of their questions to Mr. McCoy, but completely ignored his care-giving friend. This became a teachable moment. Once the students were reminded to observe the whole picture, they discovered numerous unmet needs with respect to care-givers, in addition to the direct unmet needs of the client.

Figure 1 shows the smiling faces of the students as they proudly present their prototype design solution to their client.

Back row: Students Parker Farlow, Mahdi Shoaeshargh, Jill Goryca, Mike Rogers and Engineering Instructor - Darrell Kleinke.

Front Row: Nursing Instructor - Molly McClelland and Client - Delbert McCoy.



Figure 1: Student engineering team poses with Mr. McCoy

Example 2: Client A* - Spinal condition

* The client's name and specifics of the condition have been omitted

In the middle phase of each project, a design review with the client is required. The client must give an OK to proceed. The fact that the client is not an engineer means that the students must communicate in “layman’s terms.” Since the client has no vested interest in the manufacturing of the product, their feedback is purely from the end-user’s perspective.

The student teams have to decide if they will show the client multiple design options or if they will “go for one.” Typically, the students will ask the instructor to choose which design they should pick or which strategy they should employ. The instructor cannot give a definitive answer, since the final approval will come from the client. This educational experience reinforces that engineers must learn to make difficult decisions, and that the customer will ultimately decide if the product has value. As the engineering design progresses, the team should never lose sight of the end customer’s wants and

needs. If the students have maintained communications with their client, the mid-term design review becomes a formality, but those teams that have neglected their clients have a nervous encounter in front of them.

The lesson: As you look for engineering solutions, never lose sight of the customer.

Aside note: In many cases, as the students interact with the clients, a bond is built between the students and the client. This bond invigorates the student teams, and their determination to deliver a great product becomes a very personal mission.

Teachable moment – The team conducted a mid-term design review with client A. The students decided to show only one of their design proposals, which was an adjustable arm mounted on the rear of a power wheel chair. This proved to be a teachable moment. Because they chose the right strategy, the review uncovered additional applications for the design, rather than a prolonged debate over alternative designs. In this case, client A quickly adapted to the design and began to demonstrate how it could be used in ways that the students did not anticipate.

Figure 2 shows students experimenting with alternative uses and settings that could make their design more appealing to a broader customer base.



Figure 2: The engineering team explores design alternatives

Example 3: Client B* - Paraplegic condition

* The client's name and specifics of the condition have been omitted

In the closing phase of each project, the client is presented with a workable prototype which they can keep. (Note: a liability waiver is required) The student's grade is based on the reaction of the client as they take delivery of the prototype. The client will demonstrate how they will use the device. This demonstration becomes a poignant moment during the final presentations and it serves as the ultimate test for the product.

Rather than students simulating use, there can be no debate whether the product works, because the customer does the demonstration.

A useful heuristic applies⁵:

The lesson: The customers, not the engineers, determine product value.

Teachable moment – The final product delivered to client B was not the product the students envisioned earlier in the course. In fact, they were not even working with client B. One of the risks with using real clients is that the client's circumstances may change before a semester completes. In this case, the team's original client moved to another city and became inaccessible. This became a teachable moment. Engineering projects frequently change direction mid-course. The students had to decide whether to continue with the original project (without a customer), or to start over with a new client. They chose to restart, and they re-scoped their project to account for the lost time, yet they kept the same delivery end date. This proved to be a remarkable experience as this student team had to deliver a design that was simple yet effective. They hit the mark, and the client enthusiastically expressed his delight with the device at the final demonstration.

Figure 3 shows students Mark Fazi and Ben Wansten explaining the device while their client tests it for the first time.



Figure 3: Engineering students observe the client's demonstration

Some tips for securing and managing the client involvement are provided based on the author's experience.

1. Work with a health care provider to select suitable clients. Health care providers are skilled at gauging whether the client's demeanor is suitable for the student interaction.
2. Be sure the provider understands the type of products your students are capable of delivering. This includes engineering style and quality of the prototype.

3. Meet the client before the projects start. Set the client's expectations properly. Explain that this is a student team that may, or may not, deliver a usable product.
4. Explain to client that, if successful, the resulting product may be suitable for commercialization and may have the potential to help many more people. This aspect of the project has been very appealing to the clients.
5. Accompany students at client / student meetings, but make sure the primary interaction is between the students and client.

Opportunities created by involving clients

Incorporating individuals with disabilities creates unique educational opportunities for design courses.

1. The unmet needs of the clients are unique and therefore cannot be anticipated or presumed by the students.
2. The unmet need is often unstated. Students must explore the problem statement since no prescriptive statement is available to them.
3. The design space is truly open-ended and represents an opportunity for intellectual property ownership.
4. Design reviews are designed to solicit end-user feedback, rather than a manufacturer's assessment.
5. The projects frequently become personal experiences for the students and for the clients.

Value Creation – Enabled by the Disabled

Each client presents an opportunity for the development of a novel product to address their specific need. In addition to designing for one particular individual, the student teams are challenged to consider whether there is additional market potential. The students are given a series of lectures on design commercialization and the student teams are required to develop an “elevator pitch” that presents the straw-man of a business proposal. Because the broader client base also represents an entire population of the disabled, the students are incentivized by the opportunity to help an entire community. This has proven to be very motivational. Also, since these are typically small niche markets, the business opportunity represents a “blue ocean.”⁶

The business plan exercise helps students learn how their engineering design decisions affect business operations, and likewise, business decisions affect engineering design. One interesting debate has been whether the business acumen training should come before, during or after the engineering design work. That is a question for another publication. Currently, the course is set up to present the business acumen near the end of the engineering project work. As a result, students frequently realize in hindsight that they have made expensive choices that would need to be re-evaluated to scale up from a single prototype to a full-fledged business.

From the onset, the disabled clients know that students will be exploring larger market potential. This is a very attractive appeal for the clients. Despite their personal challenges with own disability, they are eager to help others if they can. They realize that the broader impact could be substantial. The clients are conscious of the need to appeal to a broader base of users, so they consider the value to the entire community as they participate in the projects.

Of course, a vast majority of engineering students will go on to work for established companies, most of which are NOT in the assistive technology business. Even though the value creation exercise addresses a different type of client, the student's experiences working directly (and on a very personal level) with end-user customers will prove beneficial. In addition, the student's new-found awareness and empathy for the community of disabled clients will encourage them to create value for all customers, not just the able-bodied masses.

After an up-close design experience with clients that are disabled, engineering students gain a very personal appreciation for value-creation as viewed by the customer.

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