

Using a Service Learning Strategy to Enhance a Course in Concurrent Engineering

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Abstract

This paper describes an innovative course in concurrent engineering offered by the University of Central Florida and identifies a critical challenge that has limited achievement of student learning objectives: student motivation. This challenge is not unique to our course. Higher education, particularly professional education, is struggling with students' loss of motivation and engagement. The paper introduces the concept of service learning, illustrates how a service learning strategy has been incorporated into the design project component of the course, and provides an assessment of the impact on student motivation/commitment and attainment of learning objectives.

I. Introduction: A Challenge in Teaching Concurrent Engineering

The Department of Industrial Engineering and Management Systems has offered EIN 6399 Concurrent Engineering to students at the University of Central Florida since 1993. Armacost and Mullens¹ describe the course, including the rationale for teaching concurrent engineering, the teaching/learning approach used in the course and a detailed syllabus. The objective of the course is to familiarize students with the underlying philosophy of concurrent engineering and the basic tools for its implementation. The one semester course is intended for graduate students and advanced undergraduate students who will be involved in the design or manufacture of products and services. Topical coverage includes the product development process, identification and assessment of customer requirements, Quality Function Deployment (QFD), industrial design, concept generation, concept selection, Design for Manufacturing and Assembly (DFMA), prototyping, benchmarking, organizational issues, teaming, and statistical approaches for producibility analysis and process characterization.

To reinforce these concepts, multi-disciplinary student teams are tasked with conceiving and designing a new product and developing an α prototype. Project deliverables (Appendix A) are designed and scheduled to pace the development process and stimulate student contemplation of the *process*. Design teams are encouraged to generate their own projects instead of using industry-sponsored projects where the sponsor may have much of the design completed and needs help only in addressing specific design details (e.g., manufacturing). Among the more interesting products that student teams have designed are a shovel using space age materials, an executive lunch box, a personal drinking container for athletes, a drying rack for scuba gear, and a heat sensor for firemen. While adequately serving its purpose, the format of the design project has not been ideal. Student teams often demonstrate waning motivation and even apathy,

particularly in the latter stages of the project. The challenge of low motivation is not unique to our course. Cabral, Viau and Bédard² indicate that higher education, particularly professional education, is struggling with students' loss of motivation and engagement. This "just get by" attitude can result in incomplete intermediate and final deliverables which do little to reinforce key course concepts.

This paper introduces the concept of service learning, illustrates how a service learning strategy has been incorporated into the design project component of the class, and provides an assessment of the impact on student motivation/commitment and attainment of learning objectives.

II. Service Learning

Mintz and Liu³ have defined service learning as:

“a method and philosophy of experiential learning through which participants in community service meet community needs while developing their abilities for critical thinking and group problem-solving, their commitment and values and the skills needed for effective citizenship. The core elements of service learning are (1) service activities that help meet community needs that the community finds important and (2) structured educational components that challenge participants to think critically about and learn from their experiences.”

Service learning is a subset of situated learning, an approach that places students in the context of actual disciplinary practice.² A more common form of situated learning is the industry-based design project that is widely used in capstone engineering design.¹⁸ In addition to the obvious advantages offered by a real-world industrial design experience, instructors have reported that service learning has enhanced a variety of student outcomes including: engagement, motivation, awareness of human/social issues, international understanding, racial tolerance, understanding of persons different from themselves, self-confidence, self-reliance, self-worth, and leadership skills.^{4,5,6,7,8,9,10,11,12} One key driver is the fact that students enjoy doing things that “give something back to the community”.¹²

Service learning has not only benefited the community and the student. Ansell¹⁷ reports that observing the personal interface of student and patient (client) and the metamorphoses resulting in attitudes, friendships, and overall learning, was one of the most rewarding experiences of his 38 year career as an engineering professor. Gokhale and Aldrich¹² indicate that the School of Engineering and Technology also benefited from a service learning project through the publicity it received in local newspaper and on television.

While liberal art educators have been on the forefront of service learning, the engineering education literature does describe some service learning type experiences. Large scale efforts involve design of an information system for a non-profit agency⁷, design of photovoltaic electric power plant for a medical clinic in a West African village⁵, and the rehabilitation of an abandoned house.¹² More typical service learning projects involve the design of a product for the physically and/or mentally disabled. These include: a “pinch-tree” requiring the patient to perform a task, with feedback to the patient supplied electronically to give praise on completion

of the task; a device attached to the patient's foot to passively exercise it with remote control; a device for exercising using muscles of the arms; a special switch used to switch on a dancing-pig toy for a child; a device attached to a bathtub to sense when the water has reached a certain level and sound an alarm; a keyless entry system that allows a severely disabled client to unlatch her front door for a few seconds by tapping a code on her portable telephone; an alarm system to alert a user that her electric stove is untended; a "jelly bean" switch for an electric car for a four-year-old boy with cerebral palsy (allows the boy to move the car forward while the parents do the steering by remote control); a floor scooter for a child who has cerebral palsy; a door knob attachment for person with hand impairments; devices for rehabilitation clients; an eye tracker head control monitor; a drop ball game; a shoe-tying device for one-handed persons; and a motion device for children who could not experience vestibular (the sensation of moving through space) motion.^{13,14,15,16} The limited use of service learning projects in engineering may be the result of product liability issues. Burtner¹⁵ indicates that she no longer uses clients from outside the School of Engineering, since allowing an outside agent to use a product designed and built by a team of students raises liability issues.

Gokhale and Aldrich¹² recommend the following principles when developing a service learning program:

- 1) Academic credit is for learning, not for service,
- 2) Do not compromise academic rigor,
- 3) Engage students in responsible and challenging ways,
- 4) Provide a structured opportunity for students to reflect critically on their experience,
- 5) Articulate clear service and learning goals for everyone involved,
- 6) Clarify the responsibility of each person and organization involved, and
- 7) Provide feedback and assessment mechanism to all involved.

III. Implementing Service Learning in the Concurrent Engineering Class

In Spring 1999 the College of Engineering was approached by teachers at Colonial High School, a magnet school for the severely disabled in Orange County Public Schools. The high school teachers were searching for faculty and students interested in developing products for severely disabled high school students. Recognizing the opportunity, the Concurrent Engineering course faculty formed a partnership with Colonial High School. The goals of the partnership included: 1) provide a ready source of consumer product ideas, 2) provide access to consumers (disabled students) who were vitally interested in the outcome of the design effort, 3) motivate our students to excellence in the design project, and 4) develop personal relationships between the high school student "consumers" and our students.

Three multi-disciplinary student teams were formed prior to meeting with the consumers. Four engineering graduate students were assigned to each team. Each team was charged with developing a new product, from preliminary proposal to α prototype, using the schedule of deliverables summarized in Appendix A. The schedule of deliverables was critical to student success in several respects. First, deliverables paralleled class discussions on related design topics, providing immediate, real-world application and reinforcement. Second, adherence to the schedule was vital if students were to produce a high-quality, working α prototype in the 14 weeks allotted to the course. Although new product ideas were left to the discretion of the teams,

they were limited to those meeting the needs of the consumers. After several meetings, each team proposed two potential products. After reviewing the proposals for feasibility and need, the faculty selected a product for each team. Products included a robotic tray table for a wheelchair, a remote switch for electrical appliances, and a gardening center allowing wheelchair access.

Design teams held regular meetings with their customers to elicit customer requirements and discuss design options. Other customer requirements were obtained from web-based contacts. Several deliverables for the robotic wheel chair tray are shown in Figures 1 and 2. Materials and some custom fabrication were contributed by local companies under the specifications and guidance of student design teams. Course faculty mentored teams throughout the process (Figure 3).

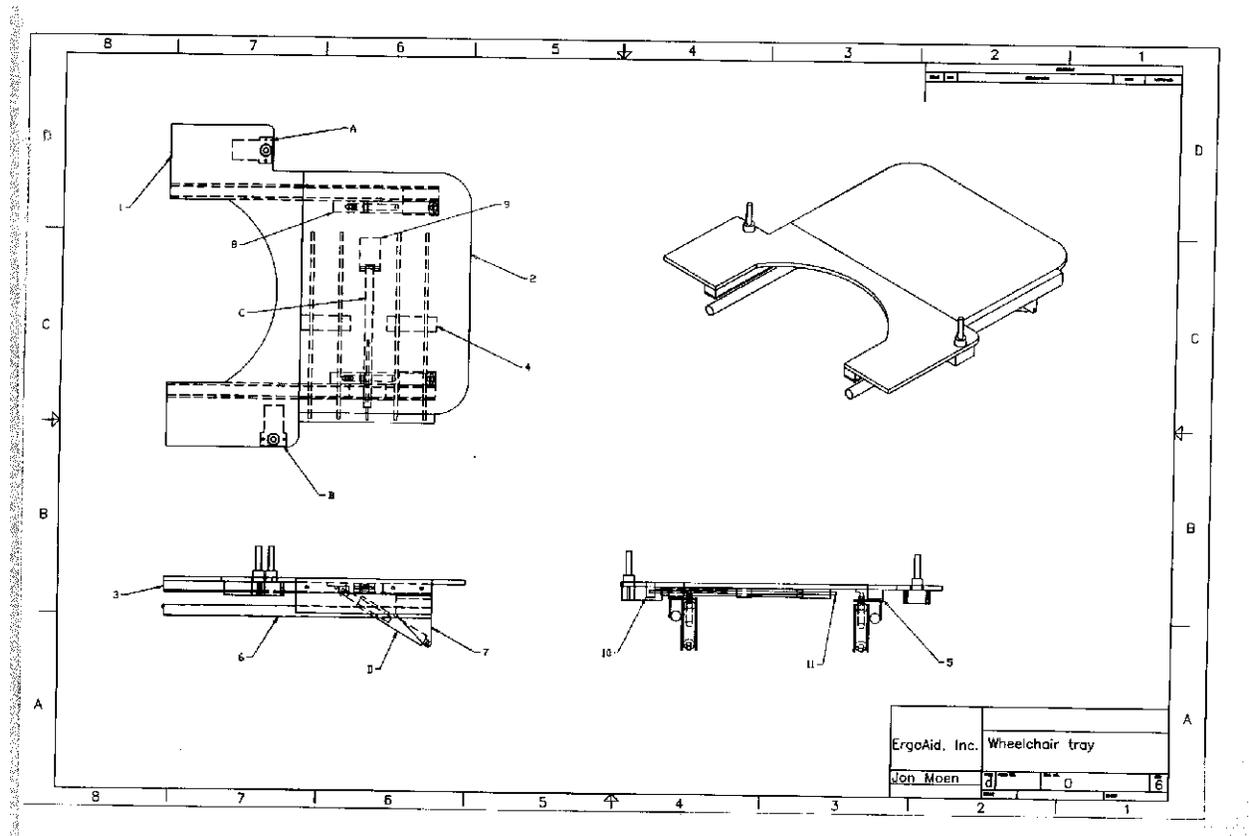


Figure 1 Final Design for Robotic Wheelchair Tray

The results of the new partnership exceeded expectation in every respect. The quality of design project deliverables was uniformly excellent. Intermediate design deliverables were comprehensive and led to progressive design refinement. For the first time in the history of the course, all α prototypes were fully functional. Prototypes were presented to the customers in the presence of local newspaper and television reporters (Figure 4). Our students reported that they had never worked so hard in a course, but that it was worth it. The results of formal student evaluations (Table 1) indicate marked improvement in student satisfaction. Our colleagues at the magnet school confirmed that priceless personal relationships were formed between both

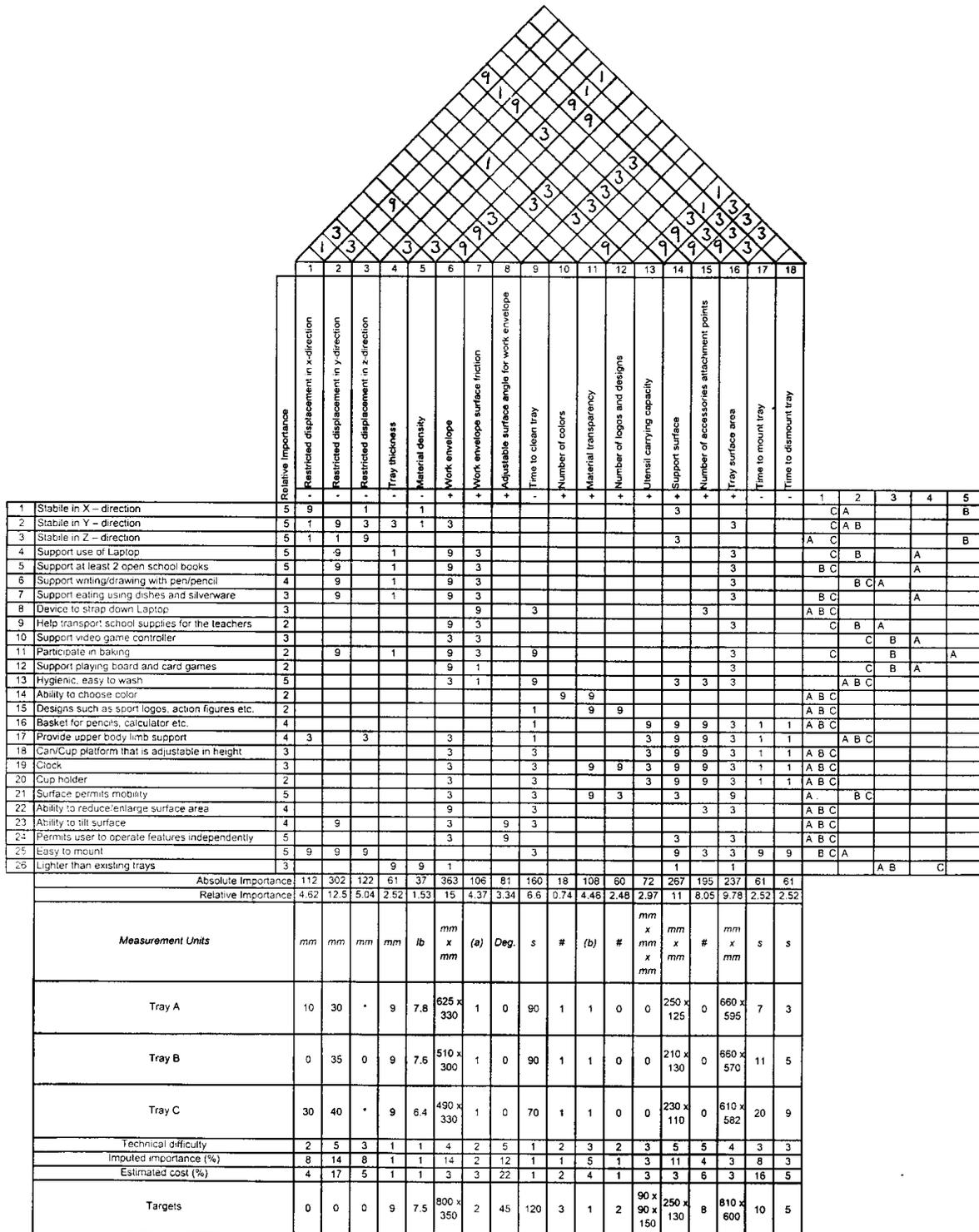


Figure 2 QFD Analysis for Robotic Wheelchair Tray



Figure 3 Faculty Mentoring



Figure 4 Product Commissioning

students and faculty and that we should repeat and expand the program. Manufacturers have been identified for all three products and the university is exploring patents for two products.

IV. Conclusions and Next Steps

Service learning in the form of developing new products for the disabled can be a powerful motivator for students. Motivated students work harder, produce better deliverables, and, remarkably, indicate greater satisfaction doing it.

Course faculty intend to offer the course, with the service learning component in place, in Spring 2000. Funding is currently being sought to offset the significant costs associated with developing fully functional, high quality products. Several potential funding sources have been identified. The National Science Foundation's BRAD program¹⁹ supports senior engineering design projects to aid individuals with disabilities. The National Collegiate Inventors and Innovators Alliance's E-Team program²⁰ supports student, faculty and advisors pursuing the development of an idea with commercial potential.

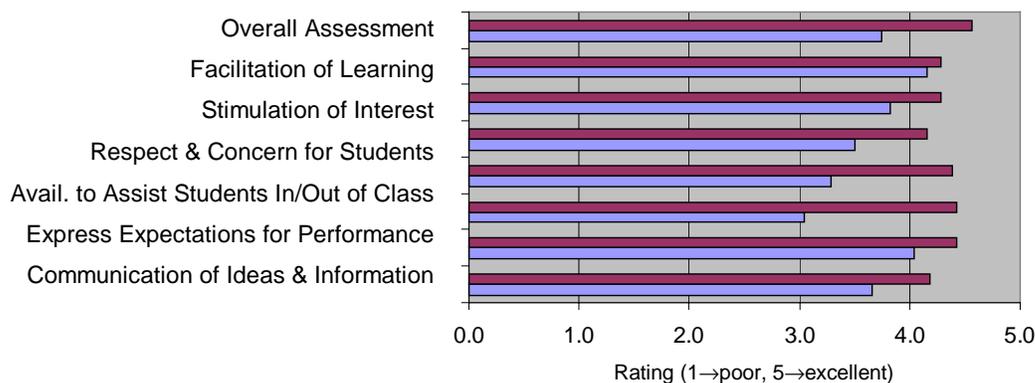


Table 1 Summary of Formal Student Evaluations

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Appendix A. Schedule of Project Deliverables

Assignment: Project Proposals

Due: 2/2/99

Each team will prepare project proposals for two selected concepts. A project proposal may use any format, but must fit on no more than three 8-1/2" x 11" pages. The proposal should identify the names of the project team members, the designated team leader and a description of the product. Your description may include any of the following: documentation of a market need, forecast of size of market, demonstration of existing competitive products, and definition of the target market. Do not present any of your own product ideas at this time--the focus is on market opportunity and not solution concepts. Include any special skills that team members possess which will facilitate working on this proposal. Your team will present the proposals to the class with a 2 minute presentation for each proposal. [The time limit will be strictly enforced.] Your proposals will be evaluated and guidance provided with regard to which one to pursue.

Assignment: Customer Needs List

Due: 2/16/99

Hand in an organized list of customer needs. Needs should be arranged hierarchically and include an estimate of relative importance.

Assignment: HOQ and Product Specs

Due: 2/23/99

Hand in the House of Quality for your product including preliminary product specifications.

Assignment: Concept Sketches

Due: 3/2/99

Hand in sketches of between 10 and 20 alternative product concepts for your project. Include a description of the steps you followed in the concept generation process.

Assignment: Selected Concept

Due: 3/9/99

Hand in a sketch of the concept you intend to pursue. Include a description of the concept selection process and any concept selection matrix which you may have used. Include the

importance of the customer needs and how they are addressed in the selected concept. Identify areas which require further resolution or may be subject to uncertainties in the design or manufacture of the product. Also identify how those uncertainties are to be resolved.

Assignment: Refined Concept and Product Specifications

Due: 3/23/99

Prepare a 7 minute (maximum) presentation on the final product concept which you are considering. The presentation should include a review of your objective, customer needs, product concept, product specifications (related to customer needs), and technical performance targets.

Assignment: Assembly Drawings and Plan

Due: 3/30/99

Hand in an assembly drawing (sketch quality) of the product, a bill of materials indicating whether parts are to be purchased or fabricated, and a tree diagram indicating the final assembly sequence of the product. Show a rough layout of the process and materials flow that you envision for final assembly.

Assignment: Part Designs and Processes

Due: 4/6/99

Prepare dimensioned sketches of each piece part to be manufactured and photocopies of vendor literature (e.g., catalog pages) for purchased components. Indicate the material and process you have selected for each part.

Assignment: ;prototype, report, and presentation

Due: 4/20/99

Prepare a 20 minute presentation about your product. Your presentation should focus on the product itself, but you may wish to emphasize a particularly impressive portion of the development process. The presentation should be high quality and include a display of the product. The alpha prototype should illustrate the appearance and functionality of the product. It is not necessary that the prototype use the exact materials that will be used in the final product. The objective of this presentation is to convince a top management group to purchase the rights to your product or to fund its final development and launch.

Assignment: Final report

Due: 4/27/99

A Final Report for each project is due on the scheduled final exam date. The report should **fully** document the development process as well as the design and manufacturing plans for the product. It is recommended that the report be structured early in the process and the various "deliverables" during the course be integrated in the report.