

Product Design and Innovation: Combining the Social Sciences, Design, and Engineering

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Introduction

It is increasingly evident that new products and services must be regarded not only as commodities in a marketplace, but also as social actors that can constrain or enable the quality of our life. In recognition of these two perspectives, *Product Design and Innovation* (PDI) is a new undergraduate dual degree program at Rensselaer that seeks to educate students for careers in new product invention and development with a sense for both the technical and social issues. PDI is a dual major program satisfying the requirements for the Bachelor of Science programs in Mechanical Engineering, and Science, Technology and Society (STS). PDI prepares students to become innovative designers who can integrate contemporary technologies with changing social contexts for a new generation of advanced product designs.

PDI aims to balance the traditional approaches of Architectural/Industrial Design and Engineering Design - often governed by the aesthetic and the technical - with the approach of Science and Technology Studies (STS) - the social. Students develop a set of general engineering skills through meeting the degree requirements for mechanical engineering, and a set of analytical skills for understanding society and culture through meeting the degree requirements for STS. But the backbone of PDI is the sequence of eight design studios, one every semester, that aim to integrate all three dimensions of the program - the technical, the aesthetic, and the social - with an emphasis on creativity and the imaginative application of new technologies and materials. The design studios help students to explore and develop their creativity while building a portfolio of design experiences continuously throughout all four years.

This paper will describe the PDI program, its goals, how it was formulated, and review experiences we have had in offering this innovative program. We will discuss how the design

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studio sequence fits together, and give some examples of how the social, technical, and aesthetic are integrated in the design studios.

Background

Over a number of years, professors from the Schools of Engineering, Architecture, and Humanities and Social Sciences (H&SS) at Rensselaer Polytechnic Institute worked together to develop an inter-school, multidisciplinary design pedagogy. That work, which included several co-taught design courses and studios, resulted in a truly unique undergraduate product design program that (i) makes concrete progress towards realizing the disciplinary synthesis called for in these challenging times and (ii) can serve as a model for other design and engineering programs around the world. Rensselaer's traditional strengths in its Schools of Engineering and Architecture, when combined with its strength in the Department of Science and Technologies Studies (STS) in H&SS, serve as the foundation upon which to base a totally new approach to product design education. STS includes faculty from six disciplines—anthropology, history, philosophy, political science, psychology, and sociology—all of whom work on understanding how science and technology shape society and how in turn society shapes science and technology. Supported in part by NSF, STS has also been working on its own focus on design as a natural complement to the traditional focus on design in engineering and architecture.

Our inter-school program, entitled **Product Design and Innovation (PDI)**, integrates these three areas and attempts to achieve the following outcomes:

- A sense of creativity and visualization.
- Sensitive perceptual and communication skills.
- Hands-on modeling and drawing skills.
- A design sense, so to speak, including an understanding of problem formulation, idea generation, and solution iteration.
- The ability to work well on teams with a variety of different people.
- Technical skills, from using machine tools and rapid prototyping to computer aided design (CAD).
- An understanding of engineering science and manufacturing.
- An understanding of the basic disciplines in science and technology studies.
- An understanding, specifically, of how a product is/will be situated in our lives, or rather, the art of reading a user.
- An ability to work at all scales of a product's context and life history.
- The presentation skills to convey all of these ingredients at once.

The design experiences in the program cultivate in students the ability to function effectively in new situations and unfamiliar environments, to collaborate with a diverse constituency to

formulate and analyze problems of varying complexity and to work individually or in teams to produce innovative design solutions that reflect this genius for integration.

The Basics of PDI

The PDI program was begun with the incoming class of the Fall 98. The institutional and administrative infrastructure for the PDI program is a dual-degree program jointly offered by the School of Engineering and the School of Humanities and Social Sciences. Students satisfy the requirements for the Bachelor of Science in mechanical engineering and science technology studies. An option also exists between architecture and STS but for the purposes of this paper, we will describe only the engineering option. A complete description of the PDI curriculum template and the associated courses is available on line⁷.

The core of PDI is *the design studio that students take every semester*, giving them a hands-on opportunity to bring together the two major curricula. The mechanical engineering curriculum includes courses in engineering mechanics and electronics, energy, materials, and manufacturing. The STS curriculum covers the social and cultural dimensions of product development and innovation, including case studies of successes and failures. Through the design studios, students have the opportunity to translate into practical terms the diverse skills acquired in these two curricula.

The Design Studio Sequence

The eight PDI design studios make up the core of the PDI experience. Two of the studios, *Introduction to Engineering Design* and a multidisciplinary capstone design experience, are existing courses taken by all engineering majors. These and the other specific studios developed for the PDI curriculum are described below.

PDI Studio 1

The first studio is taught in the first semester of the freshmen year and is offered by the School of Architecture with faculty drawn from architecture, engineering, STS, and arts. The course combines the first semester PDI students with the first semester architecture students and becomes the introduction to design practice and philosophy for both groups. Students enter this studio with very vague perceptions of what design is. Some have had an art course and have some studio experience, and some may have had an architectural drawing class, but it is rare to find someone that has had a design course. The major challenge of this studio is to acclimate them to the nonlinearity of design studio work, which is so different from the more linear nature of traditional classroom learning.

The central concerns of course are to open up ways of being in the world - through sensory awareness, through experimentation and physical engagement with artifact, site and program and through working methods for suggestive and precise communication. These studies are meant to

⁷ <http://www.rpi.edu/dept/sts/pdi/index.html>

encourage curiosity and risk while maintaining a concern for exhaustive rigor and investigation. The development of reflective judgment is a significant aspect of this course. Students are asked to reflect on the consequences of doing something in alternative ways, and determine who and what is affected by these design decisions.

The goals of the studio are,

- To make students aware of the iterative nature of design and how many factors can conspire together to influence the outcome. We typically try to concentrate on the social, technical, and social influences, but primarily emphasize how to evolve their solutions from one proposal to the next.
- To introduce the collaborative nature of the design process. Small teams and peer evaluation are encouraged so that they can learn how the studio environment can be a different place to learn than the classroom.
- To begin the development of their communication skill set, particularly as it relates to design. This includes, computer simulation and 3D modeling, physical modeling, perspective and orthogonal drawing, analytical diagramming, and verbal description.

The first studio typically begins with a series of small explorations, emphasizing broad thinking, problem research, social context, and iterative development of ideas. As an example, the telephone was used as the basis for a series of design exercises. These exercises explored representation of knowledge; the modeling of artifacts; several redesign exercises; research on the cultural and social context for the object, and exercises in observation and ethnography. Through these exercises, students begin to understand a design problem from many varied points of view, the designer, the uses, and society. In the case of the telephone, how it operates and interacts with the user is given equal consideration with the issues of how our society has changed as a result of the introduction of this form of communication.

After these short exercises, the major project is undertaken, typically involving the design of prototypes for a real community project. An example from one semester was the design of structures to aid farmers in the display and marketing of their products at the local farmers' market. The purpose of this project was to develop an expandable, collapsible, portable system of display, shelter, attachment, layout, etc. that could display, carry, or protect the farmer's produce, fliers, etc. and could be secured to the site (walls, ground, cars, bodies, etc.). Here, through exercises in observation, students studied the market for several weeks, getting to learn both the customers and the farmers. The students used the information developed from these exercises to develop their own specific problem statements rather than have them provided by the faculty.

Throughout the semester, students begin to develop skills at drawing and sketching, and the use of the computer for 3-D modeling and rendering through sessions that run concurrent with the studio. The students kept notebooks of exploratory design sketches, notes/sketches on board critiques and public reviews, observations/drawings from the weekly exercises - (self-reflective journal keeping). Along with the drawings, three-dimensional model studies, design studies and

presentation work done for the course was included in the portfolio in the form of photographs.

PDI Studio 2

PDI 2, the second studio in the Product Design and Innovation program provides students with an opportunity to continue development of their fundamental design skills, and their ability to visualize and synthesize innovative design solutions. The major goals of this studio are to allow students to enhance their ability for creative design work, to begin to understand the unique characteristics of product design, and to begin to develop critical thinking skills in a way that will begin them on a path of being creative problem finders. In addition, a major portion of the course reading and discussion is devoted to the impact that products, and designers, can have on users and society.

This studio is also co-taught by an engineering faculty member and a STS faculty member, who work together to instill in the students the incredible power product designers can have to impact people's lives. Several readings are selected from the STS literature every semester to reinforce the design work, and to require the students to reflect on the built environment as they develop their own design. Examples of readings are provided in the references^{1,2,3}.

The course is divided into two major projects. The first is a short (one month) reverse engineering project that starts with the students identifying a simple, handheld device that they have found useful. A thorough reverse engineering effort is then undertaken where students sketch, draw, and disassemble the product. They are required to develop an historical timeline of the product by researching its origins and possible patent history. They also investigate the materials and different manufacturing processes used in producing the product. They then critique the product, exploring how well it interacts with the user to perform its function, and then suggest a simple modification to the device that they feel will improve it.

The second project in the course undertakes a more complete product develop effort starting with the needs definition and finishing with the development and delivery of a prototype. The product is focused on their lives as students, and asks them to develop a new product that will improve students' lives. The emphasis, as in the first studio, is on problem finding and formulation based on observation, with students asked to constantly reflect and reformulate their problems as they work through the design process⁴. An important part of this project is the delivery of the prototype to a potential customer for evaluation, providing the students with feedback on whether their design hit it's intended target.

PDI Studio 3

In Studio 3, the focus is on industrial design presenting the traditional focus of Industrial Design in reconciling form and technology. Studio 3 provides an opportunity for students to compare how PDI is differentiated from the typical concerns of industrial design. Introductory work is done on the issues of shape and form, but the design work concentrates on how objects interface with the user. Again, as in the previous studios, STS issues related to the design work are

introduced. For example, a recent studio undertook a, *Fold, Spindle, and Mutilate*, which drew upon previous experience in working with corrugated cardboard furniture, and had the students explore how a desk and chair might be designed and fabricated in thin sheet materials for use in developing nations. In the second project, *Bluetooth Kitchen*, students examined the potential of wireless communication to transform work in the kitchen. Teams researched thermal, cleaning, preparation and coordination tools and then worked together to design a unified system. Issues of user interface, safety and the changing demographics of the modern American family were important components of the project. In the final project, *Home Alone Too*, students confronted the problems of older Americans wishing to remain in their homes and to explore a combination of products and services that might address the special needs of this group.

PDI Studio 4

PDI Studio 4 is actually an existing course in engineering, *Introduction to Engineering Design (IED)*, which is taken by all engineering majors in their second year. IED introduces the engineering design process to engineering students who work in teams of 7-8 on very open-ended design problems provided by the faculty. Examples have ranged from the design of a Frisbee™ launcher to the design of exhibits to teach science and technology to middle school children. The student teams are required to define, develop, design and build a working prototype of their design within the 15-week semester. The designs typically are a mix of mechanical and electrical systems, and are put on display at the end of the semester in an all day exhibition.

A major piece of the IED course is specific instruction on working and leading teams. Fully 25% of the course time and grade is devoted to teaching the students the fundamentals of teaming, leadership, diversity, conflict resolution, and how to recognize and deal with different work styles. More details of this material can be found in⁵.

PDI Studio 5

The fifth PDI studio is focused on the intersection between ethnographic techniques of data gathering and information technology (IT) design. Ethnographic methodology goes far beyond "user feedback." It includes participant observation, explorations of the social dimensions of technology, participatory design, and other anthropological perspectives that illuminate both the design process and the potential social impact of the finished product. IT includes both hardware and software, and ranges from new forms of communication (internet, intranet, infrared, etc) to new aspects of the human-machine interface (detection of body movement, sound, light, heat, etc). By training students to think about the synthesis between these two themes - ethnography and IT - they are able to explore mutual collaborations between product design and the knowledge of lived experience.

This semester's projects were based on design of educational technologies. The field site that allowed students to learn ethnographic skills was at an elementary school with over 90% minority children, which allows for consideration of wider social issues such as ethnic identity and economic class. We were fortunate in finding a class that allowed one-to-one pairing of

children and design students. Design students conducted three phases of ethnographic experience:

- Participant Observation: here they actively participated with students in the classroom and playground. They were directed to record field notes that included learning challenges, emotional changes, spatial patterns, and other behaviors, and then follow up with an interview with the teachers concerning these observations.
- Design probes: this assignment required the creation of a design which would produce some response in students that illuminated the aspects of learning and play that would (hopefully) be manifested in their final design. Here the value of the ethnographic technique became clear, since most of their predictions and expectations were wildly off, and many new directions were inspired. By the time prototypes were produced, a keyboard device had turned into a floor mat; a series of weighted balls became a video game, and a video game had turned into a "sensor glove" that turned light patterns into sound.
- User feedback: These working prototypes were brought back to the school for a final round of observation and refinement. Feedback from teachers on various aspects of the designs, from safety concerns to special learning needs, was also invaluable in the final assessment.

PDI Studio 6

PDI Studio 6 focuses on new technologies and their potential application in new products and services. Originally two interrelated projects were conceived to explore social, environmental and land use impacts as byproducts of new technologies. In the first project, eVelo, the studio worked as a "development team" (modeled on Nissan's California Studio) to assess characteristics of a solar versus a biomass (fuel cell) powered electric commuter scooter. In the second project "cybersprawl" students examined how devices like the cell phone support suburban sprawl and examine how new technologies might alternatively serve urban cores such as that of Troy. As the complexity of the electric bike became apparent, the concerns of the two projects were merged and students developed a center in downtown Troy where the electric bikes could be marketed, partially fabricated, assembled (using local labor), stored, recharged, and eventually, recycled. A ride simulator configured each bikes physical dimensions and performance characteristics to their potential rider. Students conducted focus groups and produced a website and animated TV commercial as part of their marketing effort.

PDI Studios VII and VIII

The final two design studios comprise the capstone experience for the PDI students. The first is the *Multidisciplinary Design Lab* (MDL) at Rensselaer that involves multidisciplinary teams of students solving industry-sponsored projects. The teams are made up of engineering students from several different disciplines, depending upon the needs of the project. The project ideas are provided by industry who provide both monetary and some technical support. The student teams become self-directed design teams who are required to define their project schedules, work with

the sponsor in defining deliverables, and “contract” with faculty for consulting help in the form of instruction to fill in gaps in background that the students are likely to find. For the PDI students, this has become an opportunity to develop their leadership skills, and to learn how to innovate in a sometimes very constrained situation. Faculty in the MDL indicate that the PDI students tend to gravitate to the leadership roles and are much more comfortable with the openness of the design situation than other engineering students. They often become the driving influence in trying to keep the design ideas from converging too fast, and are more adept at communicating their ideas. There are clear indications that these students have a better overall sense about how the design process should unfold and are comfortable with the expanding and contracting nature of the design process as it unfolds.

Students can choose to do their MDL project for both semesters, providing a full year’s experience with the design problem. An optional opportunity is to complete an individual design project, akin to a senior thesis in design. Students typically choose this option if they have an idea that they would like to pursue in more detail; it could be one that was begun in a previous semester, or one they have been waiting to explore. Students typically begin this project in the fall semester where they undertake an STS requirement for a senior thesis. By doing a research project on the context for the proposed design, the STS senior thesis can be used to research and develop the problem definition and possible criteria for the design. For example, one PDI student, who wanted to undertake the design of a soccer shoe designed specifically for women as her senior project, spent the fall semester completing an STS senior thesis on the evolution of women’s sporting goods and researching the differences in the types of injuries that women soccer players see vs. male players. The spring semester was spent designing proposals for a soccer shoe specific to the way the women play the game with the goal of reducing injuries. Just as in the case of the MDL, this curriculum option provides students with a yearlong design experience.

Assessment of the PDI Program

In the 2001-02 academic year, the PDI program directors undertook an assessment of the program in an attempt to determine if we had made any progress on our overall goals of educating a new type of design student. There were two major components of the assessment, assessment of students and assessment of the program. A focus group study was undertaken as a means to benchmark current PDI students with their non-PDI counterparts. To assess the program, an external panel of design and STS educators was formed to study the program and make recommendations to the directors. The following is a summary of the findings of these two assessments.

Student Assessment

In Fall 2001, which represented the beginning of the fourth year of the program, an outside consultant was engaged to develop a focus group assessment of the current PDI students. The purpose of the assessment was to provide feedback to the directors of the program on the content and structure from the students’ viewpoint, to determine if the goals of educating a more creative, socially aware designer were being met, and to provide material for the external

reviewers.

Approximately 70 PDI and 70 non-PDI students were recruited for the focus group study. The students were drawn from all classes. The non-PDI students were drawn from several different engineering disciplines with the majority from mechanical and aerospace engineering. The focus group was a combination of quantitative and qualitative assessments. Six focus group sessions were held, three with PDI students only, and three with non-PDI students only. The focus group session consisted of a group discussion, filling out surveys, and participation in a short group design exercise. Each session was audio and video taped for analysis later on by the evaluator.

The group discussion focused on student backgrounds, their expectations for their education, why they chose engineering or PDI, what they liked about their education, and suggestions for improvement of the program, either engineering or PDI.

The design exercise was developed by the PDI directors to determine if PDI students approached a problem in a different way than a typical engineering student might. Students were given an ambiguous problem and asked how they would approach the problem, then asked how they might solve it. The problem posed was, *“If you were given the problem of redesigning a tall kitchen shelf for a grandmother who needed help getting things in and out of the upper shelves, what question would you want answered first?”* After discussing the issue amongst them, the students were then asked, *“How would you go about solving the problem?”*

The quantitative assessment was done using three instruments, the *Science Research Temperament [SRT] Scale of Creativity*⁶, *Creativity*⁷, and a social awareness questionnaire created by the PDI faculty. The first two instruments are described in the references, the third consisted of seven design problems, each of which had three multiple-choice answers which were all possible answers but one choice was meant to determine if the student had taken into consideration the possible array of social and ecological factors that might enter into the design.

Student Assessment Findings

By the quantitative measures of creativity used in this study, the PDI students are a very creative group. Table I provides the results of the SRT test. It’s interesting to note that in the validation of this measure, the upper 10% of the most productive research workers scored 24.4. The results also show that the PDI students significantly outscored the non-PDI students.

TABLE I: SRT CREATIVITY SCORES FROM STUDENT FOCUS GROUPS

Year	PDI Students	Non-PDI Students
Freshmen	23.87	18.78
Sophomore	23.09	20.39
Junior/Senior	26.4	18.33

The *Creativity* test consisted of asking the students to generate uses for each of three drawings of objects given to them. The number of uses generated per student for all three drawings was the

score on this test. Again, in this test, the PDI students generated significantly more uses for each object than did the non-PDI students (Table II).

TABLE II: *CREATIVITY TEST SCORES FROM STUDENT FOCUS GROUPS*

Year	PDI Students	Non-PDI Students
Freshmen	15.9	10.6
Sophomore	19.3	8.9
Junior/Senior	19.4	18.6

The results from the Social Awareness Questionnaire showed no significant difference between the PDI and the non-PDI students. This questionnaire was developed without any formal validation study and is probably inadequate to draw any conclusions from.

The consultant based on an analysis of the focus group transcripts performed the Qualitative Assessment. In the Design Exercise, a number of factors were investigated including how well they defined the problem, how well they worked within the group setting demonstrating good communication and leadership skills, how many different solutions were generated, the breadth of solutions considered and the originality of the solutions, and the degree of social awareness that was included in the discussions. The following conclusions were drawn from an analysis of the sessions

- At all levels, the PDI students showed an increased ability to approach the exercise in a systematic fashion focused on problem definition.
- The PDI students produced more solutions (7-10) than the non-PDI students (4-7)
- The PDI solutions tended to have more variety and innovative aspects.
- The PDI students showed more awareness to social factors, particularly those related to age, health and psychological factors.
- There was a slightly stronger tendency for the PDI students to become leaders during the Design Exercise.
- The PDI students had better communication skills, overall, than the non-PDI students.

Relationship to ABET Criterion 4

ABET Criterion 4⁸, *Professional Component*, states that “students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political.” There are other elements to this criterion that specify math, engineering and basic sciences, as well as general education components, but there is a distinct focus on attempting to accomplish all the elements listed above on a culminating experience. The criterion suggests an ages old approach to professional education that starts with the basic sciences, then the applied

sciences, all “capped” off with experiences where the students are supposed to learn to apply all of the previous work in a practicum that is supposed to simulate professional practice. This approach is used by nearly all engineering programs and leaves much of the integration of the long list of topics given in Criterion 4 to a senior culminating experience. Many times this senior experience is just a single course. How can a curriculum hope to address all these concerns, and educate students to be creative problem solvers in a single 4, or even 8 credit experience?

A major thesis of the PDI program is that this cannot be properly done in a single course, but needs to be integrated throughout the curriculum. Using the design studio sequence as the means, students creative problem solving can be developed, while at the same time addressing many the items called for in Criterion 4. While every design studio has elements that require the student to work on skills associated with communications, and creative problem finding and solving, the themes of the successive studios address many of the issues listed above. In nearly all the studios, several of the issues are tackled in the course of doing the project. For example, in the discussion finding and defining a problem to solve, the students in Studio II watched the powerful documentary, “Sound and Fury”, which explored the impact of cochlear implants on the deaf community, and challenged the students to explore the issue of whether or not all problems that can be solved by technology should be solved. The students in Studio VI explored alternative fuel vehicles, then designed not only a vehicle but also an entire manufacturing and showroom facility within an abandoned building in downtown Troy that would support clean manufacture and economic development. Students in Studio V worked with elementary students in an inner city school to develop learning toys, then let the children pass judgment on them. The students in Studios VII and VIII explored the concept an in home elevator for Otis Elevator and built a full-scale working model in the lab, exploring issues of an aging population and the desire to stay in their own homes.

In summary, it is our opinion that the PDI program more fully addresses Criterion 4 by going away from the suggested culminating experience, instead achieving integration of these issues throughout the four years of the program.

Some Lessons Learned

The PDI program has now been in place for six years, and after this academic year we will have graduated about 18 students. Anecdotally, we see a real difference in these students versus the typical engineering graduate. Faculty teaching in the senior level design courses indicate that these students are the “only students that can think out of both sides of their brains”. They tend to gravitate to the leadership position on the senior level teams and have a good sense of how to progress through a design process. The STS faculty continually remark on the quality of the work they see in their PDI courses from these students, indicating that they seem to possess far better critical thinking skills than other students. All if this seems to reinforce the objectives we are trying to achieve in the program through the design studios.

One of the most important lessons we have learned however is that these can be real learning experiences for the faculty as well and they can inform faculty research. For the STS faculty, working with students in a multidisciplinary setting has greatly facilitated both the teaching and

research of the faculty involved. When teaching in an engineering context, typically social relations constitute a brief "front end" in the design process, and engineers will quickly ask for a list of "relevant parameters" so that they can remove any social complexities and reduce the problem to a purely technical domain. By teaching in a multidisciplinary setting we are able to sustain attention to social issues throughout the design process. Conversely, when teaching in a social science or humanities context, science and technology is often mistakenly presented as a sort of black box, alien to human feelings and sensibilities. Participation in the PDI program has enabled STS faculty to speak to engineering students about social issues in ways that are relevant to their disciplinary practice, rather than as an after-thought.

The interdisciplinary teaching and studio experience have had an impact on in the social science teaching primarily with regard to student assignments, which are increasingly based in small groups and built around problems and projects. Although the social science assignments do not involve design or prototype in the same sense that is used in the PDI studios, the basic approach has been imported into some of the social science course assignments.

For the architecture faculty, the exposure to different methods for teaching design has led to a questioning of the amount of time that art and architecture design faculty spend in the studio with the students, and coordinated this with the amount of time spent in studios around the world. This has led to more research in how people learn design, and what alternatives exist to the apprenticeship models, to the design by discovery models, and what benefits exist to the individual or collaborative models. It is becoming clearer that multiple models for design should co-exist, and that students will respond to some, but not others, and some of the time for some and perhaps different ones in any given year.

For the engineering faculty, there has been a realization that engineering education, and even engineering design education, is so problem oriented that there has been very little time for allowing students to be creative. The studios have provided a means for building a student's creative capacities and skills, and they offer a very different approach to the very structured process taught in most engineering design courses. Additionally, integration of the STS material with the design work has led to critical discussions about the role technology plays in everyday life, and the impact a designer can have on society. The ways that a social scientist looks at the world can also lead to very innovative thinking about possible solution paths that don't get considered if one is thinking in purely technical terms.

Summary

The PDI program seems to be producing a very different engineering graduate than we see from the mechanical engineering program. While these graduates have all the same fundamental engineering background that all mechanical engineering graduates have, they also have had the benefit eight design experiences versus just two for the typical graduate. The design studio clearly has a major influence on their ability to find problems and formulate ideas, reflect upon them, iterate them, and defend them. They learn to think not only analytically but also

graphically (the senior capstone faculty remark that these seem to be the only students comfortable thinking out of both sides of their brains). Just as importantly, these students have acquired a more complete understanding of the impact that they can have as designers than the typical engineering graduate. The graduates are moving to new areas after graduation as well, some considering graduate work in STS and some moving on to more design oriented careers by pursuing graduate work in industrial design. Continued study and assessment is planned but there is something clearly to be learned here for consideration of the future of engineering education.

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