THOUGHTS AND REFLECTIONS ON RENSSELAER'S PRODUCT DESIGN AND INNOVATION PROGRAM

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ABSTRACT

The experience of students in Rensselaer's Product Design and Innovation (PDI) program offers a glimpse into how to integrate the humanities and social sciences (H&SS) into an engineering curriculum. PDI offers a dual degree program built around a studio design class each semester, integrated into a core-engineering curriculum leading to bachelor degrees in both mechanical engineering and H&SS. The program is administered through our Science and Technology Studies Department in the School of Humanities and Social Sciences. The studio design courses introduce students to a broad range of open-ended design experiences, where they learn how to combine cultural, aesthetic, and technical skills and knowledge with the insight and context of social concerns and issues. As students move through the PDI program, they ultimately have culminating experiences with Rensselaer's Multidisciplinary Design Laboratory (MDL), which serve as senior capstone design studios. We have found that compared to typical engineering seniors, PDI students clearly distinguish themselves. They are comfortable and competent with multidisciplinary thinking and at odds with the conventional mindset that tends to focus on disciplinary specialization. They represent the kinds of students that organizations in industry, government and society are asking for; educated as resourceful problem solvers and first rate technical professionals. This paper offers thoughts and reflections on the PDI program, starting with its original vision and goals, a report on its current status and progress, and finally some perspectives on the future directions and promise of the program.

Keywords: multidisciplinary, design, education, innovation

1. INTRODUCTION, MOTIVATION, BACKGROUND

The engineering profession is often called upon to solve complex problems that meet society's needs. Seldom, however, are engineers directly engaged in framing the issues that ultimately guide their work. A visionary study by the National Academy of Engineering [1] describes the need for more broadly educated engineers, suggesting that the engineering profession seek better ways to anticipate social needs and to envision creative solutions. This presents a serious challenge to engineering education. The Product Design and Innovation (PDI) program at Rensselaer attempts to bridge the long lamented gap between science and technology on the one hand, and the humanities, arts and social sciences on the other. Several years of PDI teaching and learning provides evidence that we can develop young people who gracefully combine varieties of theory and practice from widely disparate fields [2].

Many first year engineering students are undecided about which field of engineering appeals to them and are unsure about what engineers do. Many have interests that go far beyond engineering and are eager to explore a wide range of options. PDI offers an attractive alternative. Students who choose PDI often have strong backgrounds in art, humanities and design along with strong preparation in math and science. PDI gives students of this kind a flexible engineering program that is responsive to societal needs and satisfies a broad range of intellectual, practical and career interests [3].

2. PROGRAM EVOLUTION AND MATURATION

Since 1999 the PDI program has graduated 15-25 students per year. While the program includes options for three dual degree tracks that students can choose, the vast majority of students so far have followed the STS/mechanical engineering dual degree template. PDI graduates have found positions in industry, with additional placements in design firms, start-ups companies, and graduate programs. The objectives of the PDI program are to educate students who can synthesize methods from engineering, social science, and architecture in the creation of innovative solutions to design challenges of the 21st century. PDI hopes to develop a replicable program model that provides a highly technical education with a solid understanding of technology and design in societies across the world.

Among the guiding values of PDI are (1) to develop designs that support democratic participation and user perspectives in design process and outcomes so that issues of race, gender, economic equality, environmental sustainability, and community needs are taken into account; (2) to develop designs that take society, culture, and human potential as a nodal point of reference for design innovation.

3 THE STUDIO SEQUENCE

The heart and soul of the PDI program lies in its studio sequence, one studio for each of the eight semesters. Many studios are taught by faculty from a variety of disciplinary backgrounds and levels of experience. The PDI studio sequence includes the following:

> Studio 1: Introduction of design as an on open-ended process, critical thinking, interdisciplinary collaboration, observation and perception, communication and visualization.
> Studio 2: Focuses on product development process with emphasis on problem definition, conceptual development and sketching, impact of design on society.
> Studio 3: Course objectives are to understand the role of visualization and representation, and relationships between form and function.
> Studio 4: An introduction to engineering design with emphasis on creativity, team work, and communication. Students are exposed to engineering design with a challenging design-analyze-build-test experience.
> Studio 5: Focuses on the social aspects of design with ethnographic techniques using design of educational technology as an example.
> Studio 6: Explores technical innovation and how design mediates the impact of new technologies on society and culture.
> Studio 7: Engineering capstone design course that immerses students in a real world multidisciplinary design experience.
> Studio 8: An engineering design elective: Inventor's Studio, independent study, engineering economics

4. CONTRASTING DESIGN PERSPECTIVES

An important source of tension and vitality in PDI comes in the way that the different disciplines and professions included in the teaching faculty express their ideas and work out their differences. The architects who teach in Studio 1 usually prefer a style of inquiry that presses students continually to question and redefine what constitutes a design problem in the first place. The social scientists from STS, involved in several studios, typically ask students to do research on a range of social, cultural and political contexts that influence what designers do. In contrast, the engineers who teach in PDI studios often seek paths of precise definition and technical closure so that students achieve real, tangible results by a particular studio's conclusion. While these approaches are by no means mutually exclusive, they do exhibit tendencies that students notice and comment upon. Engineering design tends to be convergent, recognizing "real world"

constraints, for example constraints of a marketplace that competes on quality, cost, and time, leading to demands for quick decision making and, perhaps, pre-mature convergence on design solutions. In this light, the approaches of social scientists and architects are far more divergent, expanding the range of considerations – research sites, user needs, cultural interpretations, etc. -- that designers ought to apply to their work, expecting that more emphasis upon the front end of design will produce better outcomes down the line. Obviously, there are shortcomings in both approaches. Too much convergence too soon can lead to exacting solutions that address the wrong problems and insensitivity as to why we do design at all. Too much divergence in search of ever better insights can leave us inspired but paralyzed – rich in ideas, poor in actual results. In all likelihood, these differences in how to approach design will never be resolved. Indeed, there continuing presence seems crucial to the energy and vitality of PDI. We often recommend that students combine divergent and convergent approaches to achieve balance, recognizing that faculty seldom achieve this goal themselves.

5. CAPSTONE DESIGN PROJECT RESULTS

A good measure of the success of PDI education can be seen in the senior-level capstone design projects conducted under the auspices of the Multidisciplinary Design Lab (MDL) organized by Mark Steiner [4]. The MDL provides real-world capstone design experiences to students that address a wide range of issues and encompass areas such as product quality, mass customization, aids for physically and/or mentally challenged people, entrepreneurial interests, and energy independence. MDL projects all have client sponsors who bring design problems to us to solve. While PDI students are a relatively small group (less than 12%) within the body of engineering students at Rensselaer who work on MDL projects, they often emerge in team leadership roles since they tend to be more comfortable with the many issues and iterations involved with the design process. Meanwhile, they are very capable of diving into the engineering design details, yet are far more capable of helping to properly put a problem in its social context and defining it in a way that helps to insure the right problem is being solved in the first place. The following project summaries provide a sampling of the areas that PDI students get involved with and describe the roles they have played in the MDL.

Saturn Ion Feature Concepts Development Project: General Motors asked students in the MDL to create a special options feature package that could be easily incorporated into their Saturn Ion car model (see figure 1), appealing to the "Gen Y" buyer. The Gen Y consumer is an emerging market force in the US of 60 million people currently between the ages of 5 and 20 years. Preliminary market research conducted by General Motors indicated that the Gen Y buyer had uniquely diverse interests that would guide their vehicle purchase decisions; however their needs and desires were not fully understood. The scope of the project included both interior and exterior features, encompassing all aspects of the driving experience, including areas such as, aesthetics, aerodynamics, passenger comfort, safety, vehicle guidance, and entertainment. A team of 40 students participated on the project during the course of an academic year. While only five PDI students were part of the effort, as a group their design experience and social science awareness allowed them to influence the direction and results of the team. One important result was a "generational study" by one of the PDI students that explored how societal influences shaped the thinking of prior generations. This PDI student was able to extrapolate a convincing argument for how Gen Y thinks, using it to provide design direction and propose an innovative marketing approach for the new feature package. Overall, during the course of the project, the PDI students played an instrumental role in guiding aesthetics and functional feature concept development and created models to communicate their ideas. They effectively provided design leadership, while astutely leveraging the contributions of the entire multidisciplinary design team.

Figure 1. Students with Saturn Ion

Vein Harvesting Surgical Instruments Design Project: Converge Medical Inc. had a new suture-less coupler that enabled surgeons to rapidly perform coronary artery bypass grafting through small incisions (versus open heart surgery). To compliment this development, Converge Medical wanted to develop a new minimally invasive approach for harvesting the saphenous vein (i.e., for grafting) from the leg. Several methods of minimally invasive surgical vessel harvesting have been tested, responding to the high morbidity associated with the long skin incision after traditional "fillet" style harvesting. Currently, the most common of these methods of vessel harvesting is the endoscopic vessel harvesting approach, which requires the use of insufflation devices, endoscopic cameras, and expensive disposable cautery devices. The goal of this project was to design and develop a less invasive approach, one that employs direct visualization methods involving multiple small incisions separated by skin bridges using a combination of re-useable and disposable devices. The project team (see figure 2) was mentored by Converge representatives to address the entire scope of the project including user needs, market analysis, product specifications, risk analysis, product design, development, and testing. Three PDI students worked on the project along with other students during initial phases of concept development and onto the final phases of detail design and prototype development and evaluation. Because they understood the value and importance of quick iteration of design ideas, PDI students played an invaluable role in helping the team visualize their ideas using sketching and fast model making. While PDI students did not serve as project team leaders, they contributed important design leadership, working through numerous iterations, "sweating" the details to identify better design solutions. They earned the respect of the entire team for their design knowledge, skills, and dedication.

Figure 2. Vein Harvesting Team

Posterior Walker with Lifting Seat Design Project: This project was the result of a partnership developed between the MDL and the Albany Guardian Society, an organization dedicated to the concerns of senior citizens. The goal of the project was to explore ways to help seniors maintain a more independent life style in the comfort of their own homes. One issue that can often force a senior citizen into an assisted living or nursing home is mobility: an inability to conduct simple tasks such as standing and sitting. This project focused on the design of a posterior walker with

a seat lifting feature (see figure 3), thus helping a person to stand, walk, and sit. Two of the five students who worked on the design team were PDI students, one of whom assumed the role of team leader. The PDI students showed a keen grasp of design process, guiding the team through a thorough analysis of user needs and functional requirements. Students conducted direct customer interviews with seniors and physical therapists and explored a multitude of system concept alternatives. The team ultimately converged upon the posterior walker with a lifting seat system concept. In this case, PDI students were influential in developing a productive, high performance team able to address an important social need.

Figure 3. Posterior Walker with Lifting Seat

6. CONCLUSIONS

The most exciting feature of PDI is that from the outset it seeks to educate students to create innovative products that address society's needs in a more thoughtful and integrated way. As it emerges from its start-up period, PDI offers an opportunity for becoming a model for similar ventures at other academic institutions. Most engineering design education in the United States concentrates its attention more narrowly on the creation of 'utility' and, more recently, 'usability' in products. The field of industrial design offers a distinctive approach, one often skewed toward matters of aesthetics and appearance. In contrast, current research and writing in STS analyzes and assesses the social and cultural dimensions of technical artifacts both as they take shape and after they have been created and put to use. As globalization intensifies and economic competition and the technological dimensions of societal problems become more visible, cross-disciplinary approaches to design are gaining increased attention. Design disciplines recognize the need to build networks of collaboration, including the creation of new schools of design. PDI addresses an often noticed lack in emerging design programs, offering a firm grounding in the social sciences and connecting it to a thorough preparation in the technical disciplines.

The PDI Program at Rensselaer continues its search for ways to educate young men and women who are innovators and resourceful problem solvers. Our first generation of graduates shows that it is possible to understand and, in fact, embody multiple cultures in one's work. In our studios and classrooms each day, faculty and students renew the search for design approaches – convergence, divergence or a more balanced ways of thinking -- that will change the world, for the better.

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