Cross-College Collaboration of Engineering and Industrial Design

Brian Laffitte, David F. Ollis, and Rebecca Brent

Industrial Design, NCSU, Raleigh, NC/ Chemical Engineering, NCSU, Raleigh, NC / Education Design, Inc., Cary, NC

Abstract

We report the piloting and initial assessment of a novel cross-college collaboration in which exploration of modern consumer and household devices in an engineering ”device dissection” laboratory is utilized to enhance student learning objectives and achievement in a junior-senior Studio course in Industrial Design (ID). The electric guitar and the compact disc (CD) player were chosen as first round devices. The ID students first explored these devices in teams of 4-5, discussed operation and dissection with senior engineering lab assistants, then returned to their ID studio to execute individual design responses to the initial device challenges. An unexpected dividend was the carryover to the ID Studio and inclusion there of the engineering lab assistants as part of the ideation and prototyping which is central to Industrial Design. Our initial experience was evaluated through interviews with ID students, engineering lab assistants, and design and engineering faculty. Interview results indicated two central positive outcomes: (1) device use and dissection in the engineering lab assisted the ID students in developing stronger technical comprehension and better design proposals, and (2) inclusion of engineering lab assistants in both the device lab and the industrial design studio facilitated achievement of desired, multidisciplinary design proposals. Thus, the addition of a “device dissection” engineering lab experience to an existing Industrial Design studio course demonstrated an enhancement in student performance. Plans for next year’s collaboration are presented.

Introduction

Ten years ago, the College of Engineering created a Product and Process Engineering Laboratory, within which engineering students could deepen their understanding, and satisfy their curiosity, by taking apart and re-assembling devices in their everyday lives. Early examples were light-driven devices included bar code scanners, CD players, FAX machines, and video cameras. Subsequent disciplinary expansions included electric and acoustic guitars, internal combustion engines, and cell phones. All participants in this elective engineering lab, from undergraduate enrollees, junior-senior lab assistants, and graduate student authors of individual device chapters indicated election of the lab because it offered opportunity for understanding via device use, dissection and assembly, experiences which they had found woefully lacking in their engineering education. Student understanding was deepened through the reading of a technical device description, carrying out use and assembly exercises, solving of several simple math problems to characterize device performance, and giving group oral presentations to the entire class. The engineering lab course lab was atypical in the sense that no faculty lectures were presented, nor were there quizzes or final exams.

The enhancement of learning objectives realized through such "hands-on" manipulation are several:

> Mechanical manipulation fixes mental images of devices structure and operation, greatly reinforcing and expanding knowledge obtained from the more distant verbal and diagrammatic representations of the device.
>
> Dissection is a process of discovery, in which the "peeling of the onion" reveals successively deeper principles of operation, so that the "black box" nature of many devices becomes translucent, and, finally, transparent.
>
> The student's exploration of the device is driven by curiosity, and curiosity is rewarded here, rather than punished by the parental or instructor's classic "Don't touch that" remark.

In summary, device dissection at all levels renders forms and functions apparent, illustrates clear application of general laws of nature to particular design challenges, and rewards curiosity. The typical presumed separation between academia and the outside world vanishes: the student holds, dissects, and assembles an everyday reality for which the coupling of device operation to elementary principles of physics, engineering and material science is ever present, yet without artificial or forced linkages.

The present paper reports a teaching experience in which such device dissections in an engineering lab is utilized to enhance the learning objectives and student satisfaction in a Studio course in Industrial Design. An intriguing, but unforeseen, benefit was that the interaction between industrial design students and the undergraduate engineering lab assistants created a learning enhancement of its own for students in both participating colleges.

Before reporting the complete experience, it is useful to recall the mood of the two instructional spaces involved, the engineering device lab and the industrial design studio. The engineering lab provides both working and dissectable, non-working examples of pre-selected devices. Engineering students in this lab traditionally march through a sequence of READ, USE, ASSEMBLE, CALCULATE and PRESENT activities in a 20-30 page instructional chapter within which the given, complete device is explored and explained in detail, yet deeply creative opportunities are absent. Despite the individuality of the particular devices, this chapter-driven activity sequence retains a bit of a "cookbook" atmosphere. The design studio present the complementary extreme, in which nothing is provided and the student must create everything: choice of device, ideation to create novelty, choice of materials and presentation, refining of form to provide aesthetics and cultural connections, and always, an ongoing critique and challenge by ID faculty, and class peers.

The interweaving of these complementary engineering lab periods and industrial design studio sessions created a richer sequence of device exposures than either alone. Similarly, the continued conversation between design and engineering students was found to provide a deeper, more satisfying yet demanding conversation opportunity. We now recount the starting point in Industrial Design, and the effects noted when functional devices were explored and explained, prior to realization of new device designs. In a final section, we assess and evaluate the initial pilot collaboration through interviews with ID students, design and engineering faculty, and the senior lab assistants.

Industrial Design

Industrial Design is the field concerned with the creative development of products that people use. The professional area of application is quite broad, ranging from transportation design, consumer electronics, medical products, to toys, and everything in between. The curriculum for students of industrial design is also wide- ranging, having to account for principles of visual design and aesthetics, basic understanding of human factors, ergonomics and psychology, knowledge of the materials and processes of manufacturing, and expertise in the use of both traditional sketching and computer-aided design tools.

In recent years, the myriad new technologies used in products have presented a particular challenge to design educators, because of the high level of scientific and engineering based knowledge needed in order to understand the technology for the sake of applying it creatively. Whereas in the past the typical student applicant to an industrial design program often had a long history of taking apart their toys and later, fixing their cars, the advent of both 'Nintendo' and fuel-injection has created a 'black box' syndrome among incoming students. Although there are a few particularly gifted students who rose to the occasion and learned to 'hack' their way into the hermetically sealed objects of their youth, and can now function well in both the design school and the engineering lab, most educators find this a difficult gap to bridge. Within the Design College, this situation has tended to result in student projects that fall short of achieving maximum results in terms of products technical aspect. There are also instances where the technical concept of a student's project may be possible, or even innovative, but it is difficult to confirm this with certainty.

The present NSF-sponsored development allows initiation of a design pattern similar to that which is emerging in industry, that of overcoming complexity by the use of a multidisciplinary team approach.

The Nature of Industrial Design Education

The most influential course in design education is the *Studio*. This is a 6 credit hour course that meets three days a week for three hours a day. Average class size is from 10 to 15 students. The students have an assigned desk, where they spend most of their time, even outside of the regularly scheduled class hours, building and developing their projects. The faculty member teaching the studio course has a great deal of contact with the students, both on an individual basis working at their desk, and in small groups. The studio course also makes extensive use of group critiques, where everyone is required to display their projects at various stages, and defend the validity of their work at that point. This teaching method is the heart of the design education, and the process of routinely critiquing the work from the outset of each project requires the student to continually revisit the project goals and evaluate his or her proposed solutions against that framework of criteria. This method also reinforces in the students the importance of making their design process public and visible in order to get clear feedback along the way. Another outcome expected in all studio courses is that the students, especially at the outset of a project, develop their ability to conceptualize a broad number of potential solutions in confronting a design problem, rather than relying on the first or most obvious approach. In addition, the students are required to demonstrate the validity of their design process at any point during the development cycle, not just in the final review of the completed project. It is this requirement that keeps the students from falling into a pattern of relying on a last minute 'miracle', and promotes the discipline of channeling and refining their creative ability into a professional tool. The measure of these collective outcomes is evidenced in the student's portfolio. All students begin developing their portfolios in their first semester of freshman year, displaying both the end results and the process by which they achieved those results for each of their major studio projects.

The studio courses are sequentially arranged throughout the eight semesters of the four- year of undergraduate program, with the projects becoming progressively more challenging each year. The fall semester, Junior Studio was chosen for the pilot test of the new *Product Technology Course*, because during the sophomore year, students complete two 3 credit hour service courses that deal with methods of manufacturing and the use of materials. One of the expected outcomes of the third year studio is that the projects demonstrate the students ability to effectively apply what they learned about manufacturing to the design of their projects. This studio therefore seemed a good place to include course content related to the technology embedded in the product itself.

The Use of the Laboratory

The new course was to begin by assigning the students to choose between two projects, a portable CD player, or an electric guitar. The industrial design students were to 'dissect' the product they chose as a group, under the guidance of the teaching assistants, who were graduate students in engineering. Once they understood the existing product and it's underlying operating principles, they were to develop designs for a new version of the product, based on either the current state of the technology, or an informed projection of what would be possible in the foreseeable future.

As the course was originally envisioned, the design students would work largely in the *product' take apart' laboratory* throughout the semester. We discovered fairly early in the actual course that the use of the lab had to be meshed with the Design Studio culture. At the beginning, the lab proved an essential setting for the projects, as the design students took apart the products and discussed the underlying principles of their operation with the teaching assistants. After the initial two weeks of gaining familiarity with the existing products, the faculty became aware that the students needed to gravitate back to working in the design studio. Part of the need to work in the studio was to have the desk space necessary to draw effectively, and they also required the studio's proximity to the College of Design computer lab, and shop. Both of these facilities are essential to the design student's working process, providing them with the means to produce models either in physical or virtual form. Initial product models are often made quickly, cut out of various types of foam, or modeled from wood or fiberboard. Building these 'sketch models' throughout the design process provides several benefits, such as imparting a sense of scale, or the ability to investigate how a product fits in the hand. Later models that are highly finished can be produced either in the shop or by means of computer modeling.

As the design students moved into the concept development phase, it was decided that the teaching assistants from engineering would come into the design studio, instead of only being on duty in the product laboratory, which is located in the College of Engineering. It was through this somewhat unexpected development that the course began to take on additional dimensions beyond its primary goal of imparting technical knowledge to the design students. The design studio, where each student has his or her own work area, provided a less formal setting. This fact, combined with the open layout of the room, allowed the teaching assistants to work with the design students within both individual and group sessions, and to collaborate in the development of the projects. Also, the change in setting allowed the teaching assistants the opportunity to gain insight into a learning environment different than that to which they were accustomed and to experience creatively focused learning and working methods.

A significant change was noted in the effectiveness of achieving the courses main goal, (that of promoting innovative use of technology by the students), when the teaching assistants began to take an active role in the scheduled critiques. The design critique is a setting where feedback is immediate, public, and notoriously honest. It was in this setting of verbal debate over the student's work and their ideas regarding design and the application of technology that the faculty began to see results that had been unattainable in the past. Student designs in this review were more creative in their use of technology than in the past, and technical feasibility could be proven, disproved, or improved upon, on the spot. It was particularly gratifying to witness that the teaching assistants from engineering were encouraging of the design student's creativity, even on some of the most radical ideas, and that they had become key players in shaping the details that would make a project work.

The Selection of the Teaching Assistants

We were quite fortunate in the engineering teaching assistants who were selected for the pilot test of the course, in that they both possessed qualities that we now recognize as essential to the success of the course in the College of Design. These were graduate students quite knowledgeable in their own field, and also open-minded and interested in other disciplines as well. This resulted in an open atmosphere among the students, and made them more willing to explore the overlapping interests between the College of Design and the College of Engineering. We have observed that in professional practice, there is sometimes a tendency for barriers to exist between any two disciplines, with negative expectations of the aptitudes and motivations of other disciplines than one's own taking precedence over actual personal experience. By establishing links between related professions at the university level, the way is paved for more effective collaboration in the student's future careers.

Unexpected benefits: creative design for engineering students

As Department Chair of Industrial Design, one of us (Prof. Laffitte) meets with several students each semester who come to his office wanting to transfer out of an engineering program and into industrial design. They typically express that the engineering curriculum is not offering them enough opportunity for hands-on, creative application of the information they are learning. Some of these students possess the visual and spatial ability, and sketching skills to succeed in industrial design. Those who gain admission often become some of our most outstanding design students, able to creatively apply a range of complex technologies. It is not unusual for them to mix the engineer's strengths in areas like CNC machining, the design of printed circuit boards, specification of stepper motors and power supplies, and competence at programming, with the designer's innovative approach to problem-solving, creativity, and aesthetic ability. Those who remaining engineering have a novel possibility suggested here, that of serving as a lab assistant and joining an industrial design group for a semester. We will explore the academic possibilities for credit activities next year in this regard.

Cross-college collaboration addresses challenges and needs in the ID profession and in industry

Changes in global economic forces are having a profound effect on the industrial design profession, and on all of the industries that it serves. The State of North Carolina has, over the past ten years, suffered overwhelming job loss in both the textile and furniture manufacturing industry, in the aftermath of loosened international trade restrictions. Across the country as a whole, jobs in manufacturing have eroded under the pressure of offshore competition from Asia, India, and China. More recently, 'offshoring' has begun to occur in design offices as well, and has also begun to affect such fields as engineering, architecture, and computer programming. The implication is that the ' low hanging fruit' of low-tech, commodity product design is gone, and that in order to remain competitive the profession must focus on collaborative innovation on 'high-tech' products, based on cutting edge university research, because these products are difficult to replicate by low cost labor strategies.

Assessment and evaluation

This section (on of three offered) of the junior year Studio involved 9 Industrial Design students. Each was interviewed individually by Dr. Rebecca Brent at semester's end. Taken together, Table 1 reports their comments nearly verbatim, in two categories: "Things that worked to help them learn" and "Challenges and barriers to their learning". Author remarks are in parentheses.

Table 1

Lab experience assessed by Industrial Design students

Things that worked to help them learn

Visualizing how things fit into space, "making it real".
Feedback from the engineering student lab assistants during progress display (pin-up) session.
Having the lab assistants present as a resource, especially in the studio.
Engineering assistants were not conceptually limiting; they used their imagination.
Working in a (design student) group at the beginning when in the engineering lab.
Prepared design students for real world where designers and engineers work together.
Engineering instructor was helpful in pin-up sessions and desk critiques.

Challenges and barriers to their learning

Hard to identify a problem, given a device.(i.e., no customer or safety or aesthetic complaint given)
Devices were often older devices, not cutting edge.
The separate engineering lab didn't fit with the way designers work.
Would have liked to "check out" the device and live with it while they were working. A number of students bought their own devices.
The second device (post mid-semester) activity was not well scheduled (not synchronous among ID students). Not enough time for some to do well.
Would have liked to see a woman lab assistant (ID enrollment is about 40% female).

The two engineering lab assistants were also interviewed, and their comments are summarized in Table 2 below.

Table 2

Lab experience assessed by engineering student assistants (seniors)

Things that worked for the ID students

Taking things apart in groups.
Asking questions rather than reading the (30 page) documentation.
Sketching is the way the ID students think, not reading the documentation.

Suggestions or changes they would recommend

Students didn't need the initial three days in a row in the lab. Could have moved more quickly to the studio.
Have lab assistants in the studio more than one day a week so questions could by answered more quickly (initial hour each period would be OK).
Students would be more excited if they could take the device they want to work on.
Lab needs more clear work space.

The conclusions and recommendations of the three authors are summarized in Table 3 below.

Table 3

Evaluator Recommendations and Instructor Plans Forward

Evaluator (Brent) recommendations

Acquire some up-to-date devices that are closer to "cutting edge" MP3 player, digital voice recorder_ and some that might hold interest for different learners, especially women (e.g., child safety seats, mechanical toys, motorized kitchen appliances)
Have a mechanism for checking out devices to take back to the studio
Decrease the first week time (9 hours) in the lab, and allow for a later return if needed
Have the lab assistants at the ID studio at least twice per week (full 3 hr session not needed; just a 1 hour presence to "check in" for technical questions.

Table 3(continued)

Evaluator Recommendations and Instructor Plans Forward

Instructor plans forward (Laffitte and Ollis)

Adopt above recommendations where possible budgetarily.
Provide formal introductory demonstration of device dissection, with ID students dissecting the same device in parallel.
Use periodicals (Wired and ID Magazine, as well as web pages (gadgets.com) to keep lab devices more current.

Conclusion

A novel collaboration between a Design Studio and an Engineering "device dissection" laboratory appears to have produced a favorable enhancement of the Studio learning objectives via increased technical contact with devices in the engineering dissection laboratory, thus demonstrating achievement of our NSF-funded goal. Further, learning by the engineering student assistants as they became part of the Studio teams similarly enriched their design experiences, and provided a ABET-related multidisciplinary experience for these engineering students. The similar outlooks between engineering and design faculty, and the ease of communication between engineering and design students, suggest strongly that this pilot experiment has substantial potential for mutual enhancement and enrichment of design experiences.

Acknowledgements: We are pleased to thank the National Science Foundation for support of this collaboration through our NSF DTS grant .

Biographical sketches

Bryan Laffitte is Head, Industrial Design, and Associate Professor in the College of Design of North Carolina State University.

David Ollis is Distinguished Professor of Chemical Engineering at NCSU. He has recently co-edited (with Kay Neeley, University of Virginia and Heinz Luegenbiehl, Rose-Hulman) the text "Liberal Education in Twenty-First Century Engineering," Peter Lang, publisher, New York, NY 2004

Dr. Rebecca Brent is founder of Education Design, Inc, in Cary NC. She has taught in the College of Education at Eastern Carolina University prior to moving to Cary, where she has authored numerous engineering education publications with her husband, Richard Felder (NCSU professor emeritus).