

Collaborating with Design Professionals and Industry to Build a Design Course for Freshmen*

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A two-quarter course in Engineering Design and Communication offers one answer to an old challenge: how industry and the academy can work together to improve the teaching of design. This article describes a successful collaboration between faculty in a freshman design course and professional industrial designers. Designers take on four key roles in the course: client, consultant, guest lecturer, and section instructor. The model results in a cutting edge course for freshman that yields benefits for all parties.

INTRODUCTION

FOR MORE THAN a decade now, since engineering educators have been focusing on the importance of teaching design [1], leaders in the profession have called for a closer relationship between industry and academia. For example, in 1990, John McMasters and Stephen Ford of the Boeing Commercial Airplane Group chastised industry for contributing to the ‘drift toward science at the expense of *engineering* [design] education.’ They called for more partnerships between industry and engineering schools to enhance design education and support research [2]. Similarly, in a panel at the University of North Carolina Charlotte (1994), four corporate executives and one assistant director from the National Science Foundation called for ‘strengthening industry partnerships’ to finance the educational changes needed to prepare engineering students for the future, namely, changes that will help future engineers better ‘understand the impact their projects are likely to make on society’ and improve their ability to communicate effectively, solve problems in teams, work with people in other cultures, understand environmental impact, and resolve conflicts [3].

At Northwestern, we have been working to help students improve these abilities by developing a productive partnership with professional engineers and industrial designers in our freshman design course, Engineering Design and Communication (EDC). This two-quarter, project-based course has been developed with the help of some of the country’s leading product design firms and is taught collaboratively by faculty from engineering, communication, and industry.

In this paper we offer the course as a model for a fruitful partnership between industry and the academy. We present an overview of our course, discuss the roles that our professional partners play in the collaboration, and finally discuss implementation issues and benefits. Because assessment of EDC has yielded positive responses, we conclude that partnering with industry and design professionals can help engineering educators teach freshmen a high-level design process, fostering excitement in engineering and laying groundwork for the more detailed design projects students will undertake in their upper-level classes.

COURSE OVERVIEW

Engineering Design and Communication (EDC) is a key part of Northwestern’s freshman engineering curriculum, called Engineering First. One hallmark of Engineering First is that students study math and physics from an engineering perspective in an integrated, four-quarter sequence called Engineering Analysis. A second hallmark is that students study design along with communication in EDC. EDC comprises twenty-four 16-student sections, each of which is jointly taught by a faculty member from two schools: Engineering and Arts and Sciences. A core group of faculty from each school work together to set goals, develop a syllabus, plan lectures, design assignments and activities, manage overall course assessment, and facilitate weekly meetings in which all faculty prepare for the week’s activities.

One goal of EDC is to communicate the excitement of engineering and thus motivate students to succeed. EDC does this, in part, by having students work on real projects for real clients. In the first quarter, after a brief hands-on project that

* Accepted 28 July 2002.

introduces design, four-person student teams design websites for campus departments, research groups, student organizations, local schools, and even small businesses. Working on these projects, students are coached in a user-centered approach to design, and they learn a number of analytical tools and project management techniques. Projects culminate in three deliverables: a prototype website, a written report, and an oral presentation.

In the second quarter, students work on projects that span a range of problems and disciplines. Projects come from corporations, not-for-profit agencies, entrepreneurs, and individuals. Many of the projects have a social service dimension. In spring 2001, for example, EDC teams worked on designs like the following:

- an enhanced 'spinal trainer' for physical therapists at the Rehabilitation Institute of Chicago;
- a small roller coaster toy for children with limited mobility;
- an improved cargo carrier for a minivan;
- an improved lighting system for a wheelchair user in a residential facility;
- a recumbent bike for an amputee;
- a convertible single tip/multi-tip cane;
- a device to help students with cerebral palsy play a version of basketball in their physical education class;
- a portable massage table that is easier to set up than existing models;
- a secure digital camera case that is easy to access.

A second goal of EDC is to teach students a design process focusing on user-centered design. Students learn how to define a design problem, gather information from users, generate alternatives, evaluate and test alternatives, make decisions about design, develop a prototype, and finally propose a design to a client. This process leads to conceptual designs that are supposed to reflect all relevant stakeholders' needs and requirements, but especially the needs of end users. EDC endorses the ideas of people like Don Norman, who stress the importance of developing and manufacturing products that meet the needs of ordinary people. Norman says, 'Designers know too much about their product to be objective judges: the features they have come to love and prefer may not be understood or preferred by the future customers' [4]. That is why designers need to interview users, observe them using products in their real environments, and user-test and re-test all prototypes.

Finally, a third goal of EDC is to help students see the important and multi-faceted role that communication plays in engineering. To do so, EDC teaches design and communication as interconnected and parallel processes. All the communications that students practice and produce in the course are key elements in the design process. Students learn how to write memo reports and design proposals; interview experts and users; conduct team meetings and

client meetings; hold informal design reviews and more formal client presentations. In the process, students learn that communication is not just a school deliverable; it is a productive design tool. By having to articulate and argue for their design concepts, students identify both opportunities and flaws in their designs, and they sharpen their thinking as engineers. Because communication is so critical to the success of their projects, students are motivated to learn how to communicate well.

EDC can be viewed in more detail at www.edc.northwestern.edu. Key course concepts are described in a link from that site: the EDC online coursepack.

PARTNERSHIP WITH INDUSTRY AND DESIGN PROFESSIONALS

Even a brief overview of EDC suggests how it was influenced by industry values, such as the importance of teamwork and the focus on designing for users. These values permeate the course not only because the engineering faculty typically have industry experience, but also because the faculty received help from industry partners and design professionals in planning, revising, and teaching the course. Senior executives and designers from such renowned design firms as IDEO Product Design and Herbst LaZar Bell (HLB), and from major corporations such as Amoco, Bell and Howell, and Abbott, participate in the design and implementation of EDC. This partnership, which influences every aspect of the course, distinguishes EDC from many other programs where industry representatives simply deliver guest lectures or serve as clients for student projects. Working collaboratively, NU faculty, design and industry professionals, and engineering students all learn from each other. Over the past five years, these partners have taken on key, interrelated roles that add tremendous value to EDC, namely, the roles of client, consultant, guest lecturer, and section instructor.

Client

Like most design courses that forge industry connections, we began our relationship with industry by seeking clients for student projects. Companies that had worked with Northwestern's senior design instructors stepped up to help us begin our foray into freshman design. Motorola supported projects involving designing antennas for cell phone transmission from remote hiking areas and from offshore locations. Baxter Pharmaceutical projects included an easy-to-use connecting device for dialysis patients. For UPS, student teams worked on the problem of eliminating the frequent cracking of pulleys at various points on a conveyor system. Small businesses also serve as clients for projects. Recently, for instance, a student team worked with a small, local firm that wants a new kind of packaging for medication

used by autistic patients. Similarly, a local candy company used a student team to create a new design for dispensing bubble gum, and a two-person consulting firm was a client for a website project.

Using industry and small businesses as clients has several benefits for EDC. First, it enables us to extend the range of projects we offer our students. Each quarter, EDC must provide projects for approximately 100 teams. Industry projects are a vital part of this mix. Students working with clients from business and industry can see first-hand the role played by design when it leaves the classroom. Second, our industry partnerships allow students to make contacts that lead to internships and jobs. For example, both Motorola and IDEO, an international product development firm, have offered internships to students in teams they sponsored. A team of students who designed a website prototype for a music business has been hired to implement their design. Third, industry representatives serve as additional mentors to the students, exposing them to the design and manufacturing processes used in their companies.

Most interestingly, from the perspective of EDC's development as a course, companies that originally served as clients for EDC soon began to play a larger role. Our relationship with IDEO began when they served as a client, but soon showed us how much we could learn from them and other professional designers as teachers of design.

Consultant

IDEO, after serving as a client, began to play a key consultant role in EDC. In that role, designers from IDEO's Evanston office worked with EDC faculty to identify key design skills that students must learn, developed activities to teach these skills, and trained EDC faculty to lead students through the activities. For example, since IDEO is renowned for its brainstorming techniques [5], IDEO designers taught faculty how to promote the use of brainstorming in the design process. They led faculty through a brainstorming session based on an old IDEO project. They then taught faculty members how to 'facilitate a brainstorm' and run similar facilitation training sessions for selected students from each class. Finally, these students, one from each team, facilitated the brainstorm on their teams' design projects. IDEO also provided a written guide to brainstorming techniques, which was distributed to faculty and students. The guide included these 'brainstorming rules':

1. Defer judgment.
2. Build on the ideas of others.
3. One conversation at a time.
4. Stay focused on a topic.
5. Encourage wild ideas.

The brainstorming rules have become a cornerstone of the EDC approach to design, helping

students apply techniques for releasing their creativity throughout the engineering design process.

IDEO designers have also helped faculty develop approaches to teaching sketching and prototyping as design tools. IDEO provided a conceptual framework for understanding the roles that sketching and prototyping play at various stages of the design process. They also helped us develop exercises to teach introductory sketching and prototyping skills. In one exercise, for example, students learn to use foamcore as a material for building visual prototypes. IDEO trained EDC faculty to lead a workshop in which students prototype a simple box using foamcore, X-Acto style knives, and hot glue guns. IDEO also provided us with a tutorial, *Fabulous Foamcore*, which they wrote for their own in-house training. The effect of the workshop is to make students feel confident knowing that they can make mock-ups throughout the design process to visualize and test design ideas. Since implementing this IDEO-designed prototyping activity, we have seen students do much more to integrate mockups and prototypes into their project work. As a result, a high percentage of projects culminate in thoughtfully designed and well-constructed visual prototypes delivered by student teams to their clients.

As EDC progressed, other design professionals offered suggestions, based on their practice, for teaching design more effectively to freshmen. Walter Herbst, for example, the founder and CEO of Herbst LaZar Bell, has been active as a consultant in EDC. Herbst is especially interested in helping undergraduates develop a more professional attitude toward design. One of Herbst's early contributions involved ways for us to teach more about manufacturing processes, so that students can make more informed design decisions. In a similar vein, Paul Specht, the founder and head of PBS Design, has given us valuable advice for solving one of our ongoing problems: how to help students take greater advantage of visual communication in design. Specht introduced into the course portable foamcore 'war boards,' which students fabricate and use to display their sketches, present ideas during meetings and design reviews, and storyboard their presentations. This innovation has made graphical communication a much more visible and continuous part of EDC.

Guest lecturer

The role of consultant blends into that of guest lecturer. As a two-quarter course, EDC has traditionally used its weekly lectures during the first quarter to provide an overview of design process; during the second quarter, lectures extend students' understanding of specific concepts and skills related to design. Most of our spring quarter lectures are delivered by guests from industry. Some of these are our consultants; others come in for one lecture only. In the spring of 2001, for example, designers from IDEO gave

three consecutive lectures toward the beginning of the quarter—on user observations, the role of sketching in design, and the role of mock-ups and prototyping in design ('Do it early and often—JUST BUILD IT').

A good example of how these lectures work is Amy Schwartz's lecture on user observations. Schwartz is a cognitive psychologist from IDEO who specializes in the role of human factors in design. The theme of her EDC lecture is that 'context in design is everything'. She helps students understand that a product has to be more than just a 'cool design'; it has to be something that people can and will use in their everyday environments. She urges students to see themselves as ethnographers who observe people interacting with products in these everyday environments. To encourage students to begin practicing their observation skills, Schwartz shows a short video about people trying to purchase a drink from a vending machine. She then asks students to make a chart listing their observations of people's difficulties during that task, the opportunities for innovation, and some design directions that could take advantage of those opportunities. To reinforce the main points of her lecture, we assign observation homework that involves making a similar chart for an observation they do on their own, such as observing people disposing of their trash in a fast food restaurant or finding the right key to get into the dorm. The lecture and homework culminate in the observations that students do for their projects. By that point, they have learned the value of observation and look for opportunities to do observations at different stages of their projects: early on, in order to understand the problem, and later, to evaluate users' interactions with their mockups.

In another guest lecture, Don Norman of the Norman/Nielsen group and the author of *The Design of Everyday Things*, has helped students grasp the concept of human-centered design in relation to website design. One of Norman's primary insights is that you can't just listen to what users say; you have to watch what they do. He argues that in-depth observations of five key users will yield more useful information than 50 Internet surveys. This is the approach to interviewing that we have always stressed in EDC, but Norman brings it to life in his lecture as he calls on students to perform task analyses on websites projected in the lecture room. For example, as one volunteer attempts to perform a task, others observe, while Norman explains what can be learned from the user's 'mistakes'. These 'mistakes', Norman argues, are not the user's failures but the designer's. The designer has failed in human-centered design because he or she has failed to sufficiently consider the role of the end user.

Other guest lecturers have included William White, former CEO of Bell and Howell, speaking on ethical issues students will face in their engineering careers; Frank LaFasto, who worked at Abbot Laboratories before starting his own

consulting company, on teamwork; and Bob McDonald, an engineer and patent attorney, speaking on intellectual property.

Lectures by these industry representatives allow us to draw on expertise and experiences not shared by the faculty, thus providing students with a perspective from the 'real world'. Guest lectures show that the design concepts taught in EDC really are used in industry. Lecturers first make these points to the large groups of freshmen in EDC—and then generously to faculty in small meetings after the lectures where our guests help us develop class exercises that reinforce their talks.

Section instructor

It has also been a natural evolution in EDC that industry colleagues who begin as consultants and lecturers come to serve as adjunct faculty, teaching individual sections of the course and supervising student teams. EDC requires engineering faculty to staff 20 to 24 sections each quarter, a commitment that strains the resources of the engineering school, given the other responsibilities that faculty at Northwestern—as at other engineering schools—must undertake. We have relieved that strain in a productive way by hiring professional designers and engineers to cover five or six sections of EDC each term. By opening up EDC teaching opportunities, we have been able to extend the contribution of people already involved in the course—and get new people involved. All bring their own specific perspectives and skills to their individual students and to the course as a whole.

For example, Walter Herbst has taught individual sections of EDC for four years. Students in his sections have benefited particularly from his expertise in engineering drawing and in industrial processes. In addition, Herbst has helped EDC faculty be more precise in the vocabulary related to design, giving us informal lessons on industry terminology. We feel very fortunate to have the head of the nation's largest privately held product design firm in our midst. John Lake, formerly of IDEO, began teaching individual sections in 2001, contributing invaluable advice during faculty cluster meetings. Lake suggested specific ways that faculty can convey to students the uses of sketching, brainstorming, and prototyping in the design process, and he models the IDEO style of coaching and mentoring. Similarly, independent designers Mark Kurth and Paul Specht have helped us coach students and faculty in sketching, materials selection, mechanical design, and related topics.

Industry representatives and consultants who teach EDC sections have also enriched the course with a variety of tools and techniques for promoting the students' professionalism. Two examples are noteworthy. David Sabo, of Amoco, has given EDC an effective tool to help students plan and conduct their bi-weekly meetings with faculty: an agenda format based on one used at Amoco. Student teams prepare an agenda meetings that

also indicates the meeting leader, timekeeper, and scribe. The agenda includes the topics to be covered in the meeting, the name of the person presenting each topic, the estimated time, the desired outcome, and all necessary preparation for the meeting. This form, and the thought and preparation required for its completion, have made project meetings between faculty and students more efficient and productive than before.

On the communications side, Jeanne Herrick, a communication consultant who specializes in diversity training, has contributed a 'team process check' tool to EDC; teams use the team process check to assess team dynamics and satisfaction early in their project work so that they can work together as productively and harmoniously as possible. Other industry partners have helped students with the patent process and with project documentation. With industrial designers and engineers serving as section instructors, our dialogue with industry has become a continuous part of EDC and a daily activity.

CHALLENGES AND BENEFITS

Our collaboration with industry and design professionals comes with its challenges. EDC has devoted both time and resources to insure that the students and faculty, as well as the businesses concerned, benefit from the collaboration. Working with design professionals requires significant financial resources to pay them for their services. In addition, this system requires significant faculty resources. We spend a great deal of time finding industry lecturers, briefing them on how EDC works, and helping them work out the content of their lectures. Similarly, when people from outside the university become faculty members, they require extra orientation and time with their communication teachers with whom they are partnered.

However, done well, as we believe it is in EDC, this collaboration leads to enormous benefits for both industry and academy. Our partners report that they benefit in many ways from a strong, ongoing, interactive relationship with Northwestern:

- First, professional designers have the opportunity to influence how design is taught at a leading engineering school. The engineering students being trained at universities such as Northwestern will eventually become candidates for positions in industry, as well as future clients. It is to companies' advantage to influence, through their direct participation, what students are taught about the design process, teamwork, and communication.
- Second, companies benefit from the opportunities to meet students early in their educational careers and to recruit them for internships and full-time positions. In their roles as clients and faculty, industry representatives get to know

these students well and can maintain contact with those that especially interest them.

- Third, industry representatives, in their role as clients, benefit directly from the fresh ideas and design approaches offered to them by the student teams and their supervising faculty. Baxter Pharmaceutical, for instance, had been addressing design issues in its portable dialysis units, and an EDC design team offered fresh ideas that accelerated the design of these units.
- Finally, a partnership with the academy revitalizes and re-energizes a professional design staff. The professional designers who teach at Northwestern have an opportunity to re-examine their own understanding of design process and commitment to it. They get the chance to follow this tried and true advice: 'If you want to understand something yourself, you should teach it to someone else.'

Northwestern also reaps many benefits from this collaboration, as our description of EDC must make clear. In short, we gain the following:

- *Fresh ideas and approaches to teaching the design process.* The contributions of IDEO and other designers in the last two years have, for instance, led to a new emphasis in EDC on visual communication as an essential element of design, one of our original goals for the course. These contributions can be seen in the increased instruction on sketching and prototyping that students receive as well as in their use of those visualization skills in every phase of their projects.
- *Real-world experience in engineering and business.* Freshmen often wonder whether the design process and communication skills they learn in EDC apply to the jobs they will later have as engineers. The guest lecturers and professional design faculty offer students convincing evidence that what they learn in EDC will be directly useful to them in their careers.
- *Diverse projects in many fields of engineering.* One goal of EDC, especially in the second quarter, is to offer students projects that expose them to the many different domains of engineering. Companies such as Baxter and UPS have served as clients for projects in biomedical, mechanical, electrical, industrial, and other fields of engineering. This exposure helps students make more informed decisions when they choose their major field.

Following our model, schools may worry about potential disadvantages, such as whether industry involvement at the freshman level will diminish involvement in upper-level courses. Industry connections are a precious resource and must be used wisely. However, we are happy to report that involvement with professional designers and industry partners at the freshman level has led to greater industry participation overall. Our Office of Industry Relations eagerly showcases freshmen

projects, and our industry partners enjoy mentoring freshmen because the students are so enthusiastic. Some companies who began as clients for EDC are now supporting additional upper-class projects and working with faculty in the capstone design classes.

None of the challenges in this collaboration diminishes the benefits, which are substantial for all. Thus, we foresee a long, positive relationship between EDC and our professional partners, and we recommend this kind of collaboration wholeheartedly.

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