The Web as a Model Technology in Freshman Design

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Abstract

The challenge of teaching design to freshmen is to find projects and technologies that suit their level of proficiency while allowing them to experience the design process and prepare for upper level courses. In the first quarter of a two-quarter freshman course in design and communication, students work on web site projects for campus clients. Web technology is an effective tool for this purpose because it is widely available, inexpensive, timely, easily learned (at a basic level) and well suited to teaching the processes of design and communication. As they engage in reverse engineering, generating alternatives, interviewing clients and users, etc., students learn techniques that they apply in the second quarter to other kinds of projects.

Introduction

Despite the growing trend in engineering education to have more students study design at an earlier point in their education,[1-4] many engineering faculty question whether design is an appropriate activity for freshmen. Traditionally, "engineering design" has been an activity for seniors, who have the domain-specific knowledge required to solve detailed technical problems. Design is taught in the capstone courses in their majors and is expected to culminate in a prototype with detailed plans, specifications, and calculations.

There are, however, many good arguments for teaching design to freshmen and sophomores, especially since detailed design is only one aspect of the design process. Design involves general activities that freshmen can learn, such as gathering information, generating alternatives, obtaining feedback, balancing competing requirements, and making decisions. Moreover, introductory design courses help students develop the competencies they need throughout their education and in industry–such as the ability to work in teams and to communicate effectively with clients, customers, and supervisors—and generate the excitement and motivation that theoretical courses too often lack.[5]

The challenge is to find projects that are within a freshman's technical capabilities, and that allow freshmen to experience the full richness of the design process and prepare to do domain-specific projects in upper-level courses. At Northwestern, our answer to this challenge is to have students design web sites.[6] We have found that the World Wide Web (which we will refer to simply as "the web") is an effective technology for teaching design because it is (1) convenient, (2) available, (3) well suited to teaching the *process* of design, and (4) excellent for teaching communication, a competency essential to design and to our students' general professional and intellectual development.

Background: NU's freshman design course

Our two-quarter freshmen course in design, Engineering Design and Communication or EDC, is a partnership between the Engineering School and the Writing Program at Northwestern. It is a collaboratively-taught course that is project-based, team-based, and equally focused on design and communication. By next year, the fourth year of our scale-up, EDC will be a required course for all 380 engineering freshmen at Northwestern, satisfying both their design requirement and their writing requirement. The goals of EDC are to:

- introduce freshman to the creative solving of complex problems
- nurture student's enthusiasm for engineering
- complement the more analytical courses that are part of the first-year curriculum
- improve students' abilities in written, oral, graphical, and interpersonal communication
- form a foundation for a new "culture of design" at the engineering school

In EDC, students attend one weekly lecture on design and two 16-person sections, team-taught by faculty from engineering and writing. For most of the first quarter of EDC, four-person student teams design web sites for real clients that address real campus and community needs. These projects introduce students to the different stages of design, stress a user-centered approach, involve a number of analytical tools and project management techniques, and culminate in three deliverables for clients and faculty: a mock-up or prototype of a web site, a written report, and an oral presentation.

In the second quarter of EDC, students apply what they've learned from the web projects to new projects from a variety of disciplines. Again working for local clients and supervised by a pair of faculty from engineering and communication, teams tackle such projects as a new cover for rollerblades, an enhanced pager system for volunteer firemen, a wheelchair for long-distance recreational use, a new storage system for a nearby elementary school, and an improved sound system for one of the university conference rooms.

The first quarter of EDC: web design projects

The winter quarter web design projects are intended to give students a sustained, hands-on experience in design process. Toward that end, the quarter is divided into three sections (see Table 1). During the first section (weeks 1-4), the teams work on understanding the problem they face and developing several alternative design concepts. In past years, for example, students have been asked to design a web-based alternative to Northwestern's course evaluation system, an on-line registration system for intramural sports, an on-line lottery for campus housing, and web-based support for Northwestern's new Human Resources software package. The students' first step is problem definition.

They brainstorm, conduct research, and use tools such as objectives trees (Figure 1) and morphological charts (Figure 2) to explore the design space and begin generating alternatives. During the second section (weeks 5-7), the teams present their ideas to different audiences for critique. For example, at a design review for a project involving on-line registration at the engineering school, one team presented their ideas to class members, instructors from several sections of EDC, and the Tech registrar. In the third phase (weeks 8-10), the teams conduct more user surveys and develop final designs. These are presented orally to the clients in week 11. Clients also receive an extensive written report.

All of the web projects focus on conceptual design. While students may produce a fully functioning web site for their client (at least for smaller-scale projects), they are not required to do so. Rather, the teams must produce mockups of their design alternatives for the early design reviews, and a mockup or prototype of their design for the final review and presentation. For a simple but effective mockup, a team may present their design with flipcharts and storyboards, PowerPoint slides, or a simple series of HTML pages. For prototypes, the teams construct web sites that present most of the features of the team's design—enough to convince a critical audience that the design is valid—but with the more complex functions (such as form processing, database queries, etc.) simulated rather than fully implemented. The emphasis is on presenting a blueprint to the client of what the team believes the client should do, not on building the whole product.

Week and topic:	What the teams will do:	Major assignments:
1 Introduction	Learn brainstorming and instruction-writing through a hands-on exercise.	
2 **Defining Problems**	Receive project assignment, schedule first meeting with client, begin brainstorming user needs and engineering requirements.	*(Individual weekly software labs covering basic HTML and other topics are due in weeks 2-10.)*
3 Gathering Information	Find and reverse-engineer other web sites, prepare to interview experts, gather background information on their project and client.	
4 Generating Alternatives	Continue to gather information, develop first solution-independent description of design ideas.	*Design Specification, Release 1.0*
5 Writing as a Design Process	Write a draft of a progress report for instructors, receive feedback, prepare to model several design ideas.	Preliminary Design Proposal Draft
6 Surveying User Needs	Revise the progress report, prepare a mockup of their design ideas for a review.	Preliminary Design Proposal (includes Design Specification, Release 2.0; mockup of design)
7 Conducting a Design Review: 1	Present design ideas to users and gather meaningful feedback through interviews, surveys, and user testing.	*Survey Draft*
8 Building Consensus and Making Decisions	Develop criteria for evaluating design ideas, begin to develop a composite design.	*Design Specification, Release 3.0*
9 Conducting a Design Review: 2	Present the composite design for further critique, write draft of final proposal. and get feedback from instructors.	*Design Proposal Draft*
10 Persuading	Revise final proposal; begin drafting oral presentation to client.	*Final Design Proposal* (includes Design Specification, Release 4.0; final prototype of design)
11 Final Presentation and Design Review 3	Develop final prototype; present design to client for review	*Final Presentation and Design Review*

Table 1. EDC web project outline.
A week-by-week breakdown of activities for the EDC web-design project.

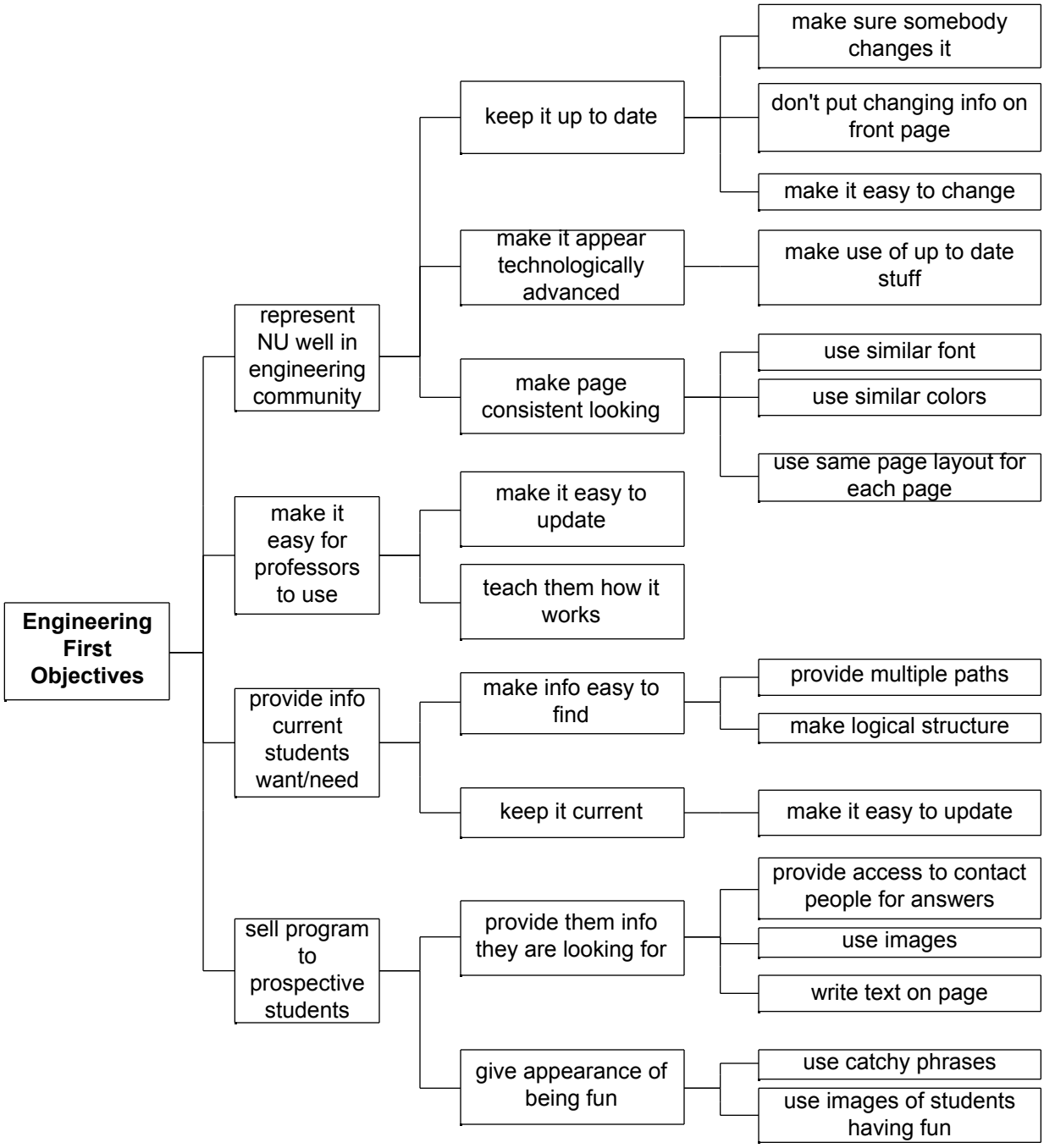

Figure 1. Objectives tree from Engineering First web site proposal.
EDC WQ 98 M. Powers, S. VanSwam, T. Worsnopp, and W. Wu.
(Engineering First is Northwestern's new first year engineering curriculum. The team's project was to design a web site that provided course information and other services to students and faculty in the program.)

Attribute	Alternatives				
Page Layout	Frames	Vertical strip	Uniform page	Frames option	
What's New?	Sort by dates	Sort by projects	Sort by subjects		
Links to Site	From other sites	From search engines	From other media		
SRG & ACT Separation	Homogeneous layout	Heterogeneous layout			
Employ colors	Warm color	Cold color	Combination colors	Black & white	Leave default
Use of logo	On background	In header	In fixed frame	On title page	
MTL geographic location	Image map	Written directions	Link to travel site	Interactive map	
Contact Information	Central page	With biography information	Phone number and email directories	Forms based email	
Screen resolution	640 x 480	800 x 600			
Links to other sites	Central page	Separate into SRG and ACT	Separate by type	Disperse through site	
Graphics	Thumbnails	Linked graphics	Dynamic graphics	With text	

Figure 2. Morphological chart showing design decisions.
Materials Technologies Lab web site project
WQ 98 EDC S. Campbell, F. Mills, P. Shein, J. Starzyk.

As students focus on web design in the first quarter of EDC, they are also being shown how the design steps and tools can be applied to other problems. For example, in the lectures where students are introduced to brainstorming and reverse engineering, they have a chance to think about drink-holders that can fit onto desk tops and about book bags that can be dropped from great heights while still protecting their contents. Students learn about finding web information on the Web itself, but they also watch a video clip of an interview with an expert in bicycle manufacturing. All of this is to remind students that our focus is not web design, but the engineering design process. Later in the course, instead of interviewing webmasters about the technical details of search engines or web-based survey forms, students may be talking to electrical engineering faculty about how to use an oscilloscope; instead of building a web site in their room, they may be in the Design Studio's machine shop building a plexiglass toy for a disabled child.

Advantages of using the web as a technology for teaching design

Initially we turned to web sites as projects for EDC because HTML and the other components of web- based design are simple enough to be accessible to first time designers, but complex enough to be interesting. Here was an abundant technology that, at our very "wired" campus, students would be able to study and use in their dorm rooms. For little or no expense, we thought, they could have in effect, their own machines for rapid-prototyping. Now, with three years of hindsight, we realize that we picked a technology that offers many advantages, particularly convenience (which exceeded our expectations), availability of projects, suitability for teaching design process, and appropriateness for teaching communication.

Web projects are convenient

Web technology is even more practical and convenient than we originally imagined. Since all engineering students need a basic understanding of computer technology, regardless of their major, many come to school with sophisticated web skills, and others can quickly learn the necessary technology. We teach the basics of HTML through required, independent tutorials that provide a good basic understanding of the different parts of a web site and how they function. For more advanced work, students can get help from the "EDC student consultants," upperclassmen in engineering who can teach students such tools as JavaScript and Perl.

Just as web technology is ubiquitous and free for the students (the software for building and viewing web sites is available for them to download or use in the public labs), so too it's free and readily available for faculty—particularly a cross-school, multi-disciplinary faculty who lack domain knowledge in common but share an ability to teach the process of creative problem-solving. Since few of us are experts on the web, we are almost forced (albeit somewhat grudgingly) to focus on process, on joining our students in a collaborative effort that focuses on problem-solving in general rather than on the particulars of any engineering discipline. No one department feels obliged to contribute more faculty or to take more responsibility than another in the EDC enterprise.

Web projects are readily available

Another practical advantage, particularly for course administrators, is that real web projects with real clients are easy to find. Course administrators have no trouble finding campus clients who want well-designed, interactive web sites. We solicit projects by e-mail and word-of-mouth, encouraging departments, programs, and clubs to contact us if they want a student group to design or improve their web site (see Figure 3).

Does your organization need a new web site design?

Currently, we are looking for clients in the University and Evanston community who have World Wide Web projects our students can design during Winter Quarter. We are willing to consider any kind of project that has a real client, meets a real need, and involves some design challenge for our students.

Client benefits of working with EDC

By becoming an EDC client, you can experience a number of benefits:

- in-depth research on your design problem and solution
- a design solution that is based on user needs
- a final written report that will present the research and the proposed solution
- opportunity to work with enthusiastic and committed design team
- the opportunity to contribute to engineering students' education

While we cannot promise that our students will have a completed web design that you can publish at the end of the term, our past clients have been pleased with the innovative ideas that result—and the head start they get in designing and programming a web site.

Figure 3. Excerpt from a letter to potential clients for EDC web projects.

This is a huge advantage for a course that emphasizes the importance of user needs in design. A key part of EDC is showing students how to identify and analyze user needs in generating alternatives and developing detailed product requirements. In fact, since the design process is just as much about defining the requirements as it is about finding ways to meet those requirements, students learn to use their design concepts to probe users and clients further about what their web site is supposed to do. Thus it's important for students to have access to real clients and real users so that the design teams can get feedback at several points during the quarter.

Since EDC emphasizes the role of users as final judges, student designers get to see how client, user, and community needs sometimes coincide but at other times diverge and conflict. For example, freshmen at the engineering school may want a web site containing information about their class that is informative, cool looking, and easy to use, but the school may primarily want a web site that is easy to maintain and runs on existing servers.

When we solicit projects, we explain that EDC is a design course–not a pool of student workers–and that the students' expertise varies. But we promise clients that they will

receive a wealth of ideas based on fairly thorough user interviews and analysis of alternatives. And we promise students a design experience that includes a number of real-world elements. They know that their designs may soon be on the web for all the world to see.

Web design is highly suitable for teaching the process of design

The web is a highly effective medium for teaching design process—the steps of creative problem-solving as we approach them in EDC. For example, web projects are easy to reverse engineer; they're easy to research in other ways as well; they're easy for surveying users; they present interesting engineering challenges.

Reverse engineering is particularly easy with web sites. There are model systems on the web for just about everything and many problems with existing designs. In non-destructive, reverse engineering exercises, students can ask critical questions about how and why a design works the way it does, and whether it meets the needs of its various users. How long do they have to wait for the graphics to download? How many clicks does it take to find the information users need? How easy is it to return to the home page and main menu? How much must the user know about the site's purpose and makers in order to figure out how to use it? What specific HTML tags, images, scripts, etc., are used in the site, and why were these components chosen rather than others—and are there other ways of getting the same results?

Using reverse engineering to expand their notions of research, students can begin to see themselves as designers rather than simply consumers of the web. They can break free of their high school notions of research, in which they identify "research" with the library research they're required to do for a specific "research paper," and instead begin to develop an engineer's view of research. They can gather additional information by interviewing web experts and by checking on-line guides to web design such as the Yale Center for Advanced Instructional Media's Web Style Guide.[7]

Web projects allow for easy access to target users and meaningful, face-to-face user surveys that give student designers a wealth of crucial information. For example, in designing a web site for a student organization or residence hall, student teams can easily get feedback on their alternatives. By presenting several designs to target users, the design team can gather first-hand information about how people will use what they build. We have found that target users are willing to donate their time to attend focus groups and interview sessions because they know that the new web site will benefit their organization. They're serious and honest about the reactions they give to the EDC student designers.

Once the teams have gathered useful information and carefully defined their problem, their web projects present them with many interesting challenges beyond reverse engineering and user testing. Teams need to make numerous engineering decisions, such as:

- whether a web-based solution to a problem offers an advantage to existing solutions (are students really better off buying football tickets on the web rather than calling the Athletic Office; are they better off getting their questions answered on the web instead of meeting in person with their academic adviser?)
- what kinds of web-based media—text, images, sound, video—will fulfill their clients' needs, and why?
- how can they build web sites that are complex but manageable—sites that offer interesting and interactive experiences for their users while being easy for their clients to maintain and update?
- how can they build web sites that are rich in features but still compatible with older browsers, slower computers, and slower network connections—in other words, how will they design for a wider audience?

Web projects are highly appropriate for teaching communication

Finally, using the web to teach design is also an excellent way to teach communication, and allows us to highlight the similarities between design and communication–the other focus of our course. This happy coincidence is hardly surprising since both design and communication are iterative, audience- or user-centered problem-solving processes–and since good communication improves design and vice versa.

Web projects help us reinforce these ideas—our rationale for teaching an interdisciplinary course in the first place—because web sites are read as they are used. Readability on a web site is as much a matter of word choice, phrasing, and content as it is of images, links, and topologies. Since web design is changing what people mean by communication, it provides as many new challenges for the "writers" in our course as it does for the future engineers.

Students begin to see how design encompasses both structure and content. They begin to understand that writing is not just a matter of grammar and punctuation but of logic, graphics, and persuasion. Oral presentations become media events where students use PowerPoint slides, web prototypes, and print handouts. Their deliverables go to a real audience, who are mostly impressed and complimentary, but can also be critical. This is a powerful way to teach students about process, audience, and professionalism —key elements in any communication course. And the web focus enhances this process because the students can deliver such impressive final products in such a short time.

Conclusion

Despite our successes, we must admit that the web is not a perfect technology for teaching design. We have struggled to define for ourselves exactly what things like "engineering requirements" and "design specifications" mean when translated into the domain of web design. Moreover, while the basics of web design are easily learned, the details of web-based applications can become daunting to both students and faculty. Engineering faculty in particular may feel their lack of experience with web-related technologies most keenly, since they may sometimes know less than their students about the details of how a particular feature of the technology works—not the usual order of things in a freshman engineering class. Finally, not all students respond with the same level of enthusiasm; some would rather build physical objects than design web sites.

However, we have found that the choice of the web represents an intelligent compromise between our desire to have our students do real design in EDC, and our need to give them a thorough grounding in the principles of design before they can do so effectively. When compared to other alternatives we considered for the first quarter projects—such as case studies and other projects without real clients—the web based projects win by giving students the opportunity to make real things—if not physical things—for real people. This leads the teams to take more ownership of their projects than they otherwise would, and as a result their first contact with the concepts and strategies is made more productive. They produce designs and documents in the first quarter that are quite creditable, and go on to do design projects in the second quarter that are often astonishing.

The web has enabled our students to model their solutions to complex problems without knowing everything they will know later about their specific field of engineering, and this experience of problem solving—of doing real design as a freshman—encourages them to model the behaviors of teamwork, creativity, and attention to the users' needs that will make them more effective designers and communicators in their future.

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