Design as a Liberal Art

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Abstract

Design is an activity that spans many disciplines and professions. In engineering, we associate design with the process of using mathematics and science to devise technical solutions to particular needs. Other fields, however, view design quite differently, but because design is a shared activity, with multiple faces, it can serve as a unifying theme for courses that bridge engineering with the traditional liberal arts.

At Bucknell University, the College of Engineering has offered two courses to liberal arts students that explore various linkages between technology and the liberal arts. The first such course called *Form and Function: Design in the Natural and Fabricated Worlds* is offered to upper-level liberal arts students, as well as engineering students. *Form and Function* deals primarily with how the form of an artifact is related to its function, where the function is broadly defined to encompass non-technical perspectives including art, economics, history, psychology, religion, etc. The second such course called *Designing People* is open to first-year students living in our residential college for Society and Technology. Here the students have a shared living and learning experience with like-minded students. *Designing People* focuses less on the artifacts of design and more on the people who do design and how society is affected by technological decisions made during the design process.

In both courses, students learn by doing. Since design is primarily an action or process, and less so a subject for passive reflection, we frequently engage students in studio-style, creative projects. By involving students in design projects, they learn the challenges and joys of design first hand. Our goal is to have the students appreciate that technology is not a mysterious force over which nobody has any control, but rather can be the product of their own minds and hands. We aim to empower them to exert active control over the direction that technology takes by involving them in the decision-making process that leads to technological innovation.

This paper will present information on the underlying philosophy, the course content, and special challenges of this style of instruction for liberal arts students.

I. Introduction

The Common Learning Agenda, a general education document at Bucknell University, states that our liberal arts "students must be led to consider the economic, environmental, and social influences and effect of technological and scientific worlds even as they comprehend them on their own terms." Courses that meet this requirement may be found in almost every department in the university, each reflecting the style of inquiry of that discipline. Many courses that explore technology and society rely on a reflective mode of inquiry in which students read texts and respond in discussion and writing to their contents. While often valuable, this approach runs the risk of leaving students with the impression that technology is a faceless, inevitable force that impacts society (embodied by the students themselves) in mostly negative ways.

In the College of Engineering, we have identified design as an effective activity for teaching liberal arts and engineering students how technology and society interact from the perspective of the creator of technology, the designer or engineer. The underlying goal of two courses offered by the College of Engineering at Bucknell is to let students participate in the design process, and by doing so, to empower them to guide technological change.

The two courses, *Form and Function: Design in the Natural and Fabricated Worlds* and *Designing People*, take somewhat different approaches. *Form and Function* focuses on the results of design, artifacts themselves, and looks at what functions the form of the artifacts fulfill. Whereas, *Designing People* deals primarily with the people who design and use the products of design.

In *Form and Function*, the function is broadly defined to include the usual physical behavior as well as aesthetic, economic, historical, religious and social uses for the object. For example, the architecture of a medieval cathedral is examined as a synthesis of how the powerful church leaders controlled enough resources to build enduring monuments with flying buttresses that distributed the material stresses in the stone while allowing the light of the heavens to enter the windows. *Form and Function* also explores how the naturally-occurring forms of objects such as bones, trees, rivers, blood vessels and seashells evolve or adapt to fulfill their functions. For a wide range of naturally occurring and fabricated objects, the students consider:

- How the object works,
- The physical, historical and cultural context of the object,
- The natural origins of form and the human activities associated with design.

Even though the initial and superficial emphasis of the course is on the objects themselves, the real goal of the course is have the students understand how society shapes our fabricated world.

While *Form and Function* targets upper-level students, *Designing People* is offered to first-year students in their first semester. *Designing People* is part of Bucknell's Society and Technology Residential College, one of six such colleges that incoming students may choose to live in during their first year. (The others are Arts, Environmental, Global, Humanities and Social Justice.) In a residential college, roughly 60 students live in a shared dormitory space, take thematically-linked classes and have access to group activities such as retreats, field trips, speakers and films. The Society and Technology College, now in its second year, offers the courses, *Internet Worlds, Exploring our Digital World, Technology and the Economy*, and *Designing People* that address the following questions:

- How does technology come about and what is its relationship to the people that create it?
- Do we lose control over collective decision making through uncritical adoption of technologies?
- Does technological change contribute to gender, racial and class-based inequality, or reduce it?
- What sorts of unanticipated consequences spring from some technological changes?
- What should be done about them?

Of these courses, only *Designing People* uses design as a primary pedagogical tool. The others are taught by faculty from our College and Arts and Sciences and rely mostly on the read-and-reflect mode of inquiry.

The sections that follow offer more detail on the content and methods used in *Form and Function* and *Designing People*.

II. Course Structure and Instructional Methods

Form and Function is taught with 3 one-hour class meetings for lecture and discussion and a two-hour studio session each week for more extended exercises in design or experimentation. The topics of the lecture sessions are given in Table 1. Most of these topics were introduced through a combination of slides, physical demonstrations, hands-on exercises and discussion of assigned readings. The studio sessions (Table 2) were used for longer activities such as design projects, simple experiments and films.

Structural Forms - Structural Elements and Famous Buildings
Vibrating Forms - Earthquakes, Auditorium, Musical Instruments
Flowing Forms - Drag and Flow, Streamlining, Automobile Styling
Connecting Forms - Graph Theory, Floor Plans, Network Design
Filling and Symmetric Forms - Packing, Patterns, Islamic Art
Self-Similar Forms - Trees, Blood Vessels, Rivers, Fractals
Origins of Form – Growth, Diffusion, Adaptation, Evolution, Manufacturing
Perception of Form – Natural and Artificial Cognition
Aesthetics of Form – Classic Proportions, Environmental Aesthetics

Table 1. *Form and Function* Class Topics

Tour of Structural Testing Laboratory with Demonstration of Destructive Tensile Test
Design, Construction and Test of 18-inch Towers made of Drinking Straws
Computer-Aided Structural Design with MultiFrame®
Drawing in Perspective
Analysis of Proportion in Classical Architecture
Measurement of Auditorium Reverberation Time
Spectrum Analysis of Musical Instruments
Wind Tunnel Drag Study of Student Carved Car Models
Film: *Tucker: The Man and His Dream* (University President, Bro Adams, was an extra)
Automobile Design in Clay
Platonic Solids and Space Truss Modeling in Toothpicks and Marshmallows
Islamic Pattern Making
Measurement of Tree Branching Patterns (affectionately dubbed Tree-Hugging)
Film: *Buckminster Fuller: Thinking Out Loud*
Design of Lamps
Field Trip to New York Museums: Natural History, Metropolitan Museum of Art, Cooper-Hewitt National Museum of Design, Museum of Modern Art

Table 2. *Form and Function* Studio Activities

Given the diverse backgrounds of the students, a single, rigid method of evaluation seemed inappropriate for *Form and Function*. In the spirit of pedagogical experimentation, the students were essentially allowed to submit whatever they chose to submit for evaluation. Each student was expected to make a brief (5-10 minute) presentation summarizing his or her work from the previous two weeks. They were given the freedom to submit any original work that was inspired by the current topics such as:

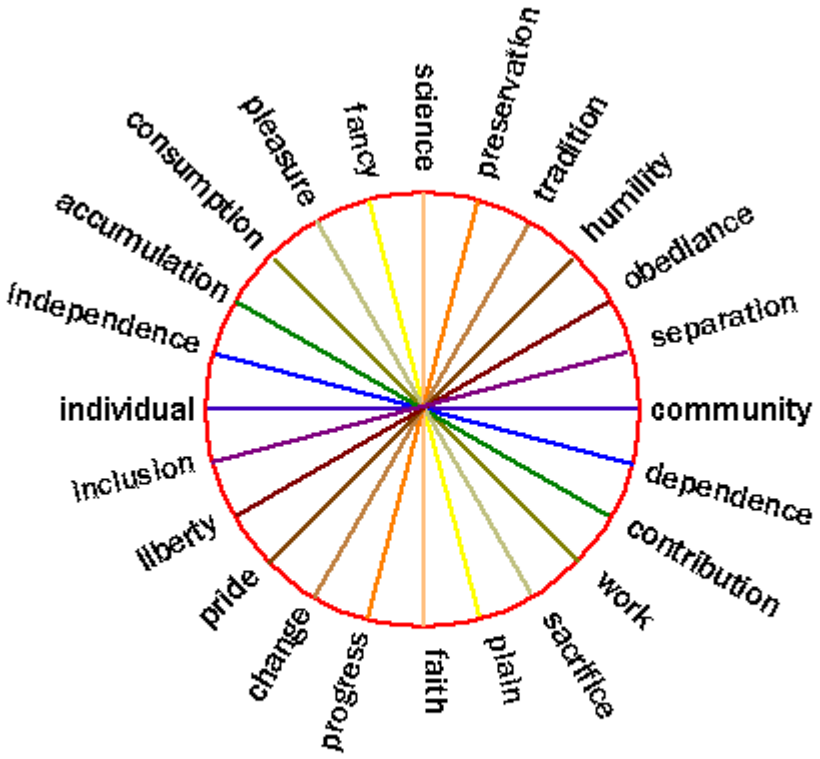
- Original designs
- Research papers
- Photography
- Analysis of forms
- Exhibit development
- Models or drawings
- Fiction or poetry
- Computer graphics
- Web-site development
- Experiments

The students were instructed that the best submissions are those that demonstrate mastery of course concepts or creative application of course concepts and those that can best benefit others in the class. In practice, the presentation days evolved into elaborate show-and-tell sessions with some students bringing a constructed object to show, while others summarized books that they had read during the preceding weeks. Presentations during the final session were expected to be more comprehensive and integrative of the course. Some of the better final projects included a scale model of a racing sailboat superstructure and sail aerodynamics, a full-scale simulation of the circulatory system during the embalming process (by the son of an undertaker), a computer simulation of a bacteria colony, and a sling chair with a tension integrity structure built with Japanese joinery.

Designing People is taught with 2 one and one half-hour class meetings per week. The students explore the art and science of design by studying past designs and by directly engaging in design as individuals and as members of design teams. *Designing People* simultaneously develops along two threads throughout the semester, active design and reflection on existing designs and designers. In the reflective thread of the course, we have used readings on the Amish implementation of technology as well as other readings on things that influenced automobile design during its first half-century. With Bucknell located adjacent to settlements of “plain” people, we are able to help our students see the Amish not as peculiar anachronisms, but as a technologically savvy society. In particular, we aim to have the students see that a society can make active decisions about which technologies it will adopt and that those decisions directly reflect the value system of the society.

Through this study of Amish society, a model has been developed to help students see how societal values can come into tension when technologies are being designed, developed and/or evaluated. It is called the "Communal Values Clarification Model" and is shown graphically on the following page. The communal values indicated along the right-hand side of the wheel are ones traditionally held by Amish communities and guide their acceptance or rejection of a given new technology. The value shown on the opposite side of each diameter indicates the communal value often found in conflict. Students quickly see how current American society often gets into dilemmas in evaluating technologies because of unclear sets of values or a lack of awareness of inherent conflicts between certain values.

Our study of automobile design serves to engage the students in a case study of how important figures such as Henry Ford, Alfred Sloan and Harley Earl have helped to shape our economy, landscape, aesthetic tastes and lifestyles as well as our automobiles. From here, the students are prepared to discuss other technological issues such as genetic engineering, Internet privacy and e-commerce.



Communal Values Clarification Model

On class days that alternate with the reflective discussions, the students engage in design projects. Initially, some of these are short exercises such as reverse designing of telephones, paper-folding puzzles, pattern making, or cartoon-style user instructions for an everyday object such as stapler. Later in the semester, the students are formed into teams to undertake more extensive projects.

In its first year (Fall 1999), *Designing People* student teams designed a collaborative learning classroom for teaching design that was actually being planned by the College of Engineering for an expansion of the engineering building. At the end of the project, the students presented their concepts to a panel that included several faculty involved in the project, the director of Bucknell's Physical Plant staff and an architect from the firm that was ultimately contracted to complete the final design. In the second year (Fall 2000), the students designed an interpretive exhibit for a working replica of an 18th-century waterwheel and pump from a Moravian settlement in Bethlehem, Pennsylvania. The original system was the first powered waterworks in America. The 1/4-scale replica, itself, had been completed the previous year by mechanical engineering seniors as their senior design project. The *Designing People* class was asked to develop design concepts

for exhibiting the hardware in a way that would interpret its significance and function to visiting tours of elementary and high school students. The final presentation of the museum concepts was made to a panel of three members of the museum staff who traveled to Bucknell from Bethlehem and hope to use the student ideas in grant proposals to support the exhibit.

The design projects in the past two offerings of *Designing People* had a number of shared characteristics. Each project:

- Was technically accessible to first-year students without highly specialized skills,
- Was complex enough to require a team for successful completion,
- Involved a product that had strong societal interaction,
- Had real customers for a real product,
- Had enough aspects to appeal to a broad range of student interests.

Physical principles in both courses were taught with visual, tactile and graphical means as opposed to the analytical and computational tools that are typically employed in the engineering sciences. Qualitative reasoning rather than quantitative methods were emphasized for two reasons: first the belief that the early stages of a design process rely mostly on such rule-of-thumb style thinking and second the need to make the design process accessible to math-shy students. For example, the effects of aerodynamic drag on automobile styling were investigated in both classes without actually calculating a Reynolds number. Instead the students considered what effects size, speed and shape had on the results of a simple wind tunnel experiment involving balsa-wood models of various shapes. They considered each influence on the drag as a ratio relative to a baseline case. Other examples of this approach included, introducing moments of inertia through a manipulation of models with identical weight, but differing inertia tensors; and studying arches and buttressing by building a desktop wooden model. In each case, the goal was not to gain proficiency with symbolic manipulation of the mathematics, but to gain a qualitative understanding of the physical processes. Keeping the mathematics accessible is a key element of the course for student understanding, leveling the field for the various student backgrounds and recruiting hesitant arts and humanities students.

III. Closing Remarks

Bucknell is an unusual institution in that it has a vigorous engineering college embedded in a much larger liberal arts institution. Our engineering students study with the liberal arts students as part of their general education requirement, but the converse has not always been true. Bucknell's liberal arts students have traditionally been reluctant to venture into the engineering courses. We have found that design, as taught in *Form and Function* and *Designing People*, makes an appealing means of introducing liberal arts students to some of the special ways that engineers think and work.

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