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THE ENGINEER IN THE MUSEUM:
Helping Engineering Students Experience Technology as an Art

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In *Getting Sued and Other Tales of the Engineering Life,* Richard Meehan describes the process of design and the satisfactions of being a designer:

> I learned the pleasure in it, in this design, the satisfaction in making a clay bowl or a painting or writing a sentence or a symphony. First the concept, the trial efforts, the crude shape of a good solution, the refinements, balance, and polish until the final arrangement sings with deceiving simplicity and stuns with accuracy of effect. . ..1 was able to experience technology not as the stepchild of science (which is, after all, impotent) but as an art. [1]

The experience Meehan describes is clearly aesthetic, characterized by pleasure and the perception of elegance. From an engineering educator's perspective, it is both noteworthy and regrettable that Meehan first experiences technology as an art not during his four years of undergraduate education in civil engineering at M.I.T. or even on his first job, but only after many years as a practicing engineer.

Many engineering students fail to recognize the artistic and aesthetic dimensions of engineering. As one such student put it, "There is no aesthetic dimension to engineering. This is an engineering school, not an architecture school." Yet numerous scholars from a variety of backgrounds have identified the important role that creativity and aesthetics play in engineering design.[2,3,4,5,6] Qualities variously referred to as elegance, sweetness, and simplicity are used as criteria for accepting or rejecting models and hypotheses and in predicting the acceptability and performance of possible designs.[7,8,9] The problem, then, is not to establish the common ground of creativity shared by art and engineering or to identify the role that aesthetic responses and criteria play in the design, evaluation, and appreciation of the products of engineering. Rather, the problem is one of overcoming the biases of culture and of engineering education that lead students to overlook the aesthetic dimension of engineering; the need is to make the aesthetic dimension real and to make it relevant to engineering students.

This paper describes a set of experiences designed to help engineering students experience technology as an art. The heart of the strategy is an innovative approach to using art museums as a context for exploring the aesthetic dimensions of engineering. Two interactive tours of an art museum at the University of Virginia are combined with preparatory and follow-up activities to help students experience and appreciate the artistic and aesthetic dimensions of engineering. The tours and related activities, which form the core of a study entitled "The Engineer as Designer," are part of a fourth-year required engineering course entitled "The Engineer in Society."

CONCEPTUAL FOUNDATION: Blurring the Distinction Between Engineering and Art

The guiding strategy involves blurring but not completely obscuring the distinction between engineering and the fine arts by increasing the students' awareness of design as common ground shared by the two. We blur this distinction using four different conceptual tools.

1. Lump all products of human design into the category of "artifacts" (literally, things made by art or skill) and think of all design as the process of turning ideas into reality. In this view, both the *Mona Lisa* and an advanced microprocessor can be viewed as products of a series of design decisions in which nature, culture, and the designer furnished resources, imperatives, and constraints.

2. Think of ENGINEERING in terms of art to bring its aesthetic and creative elements into relief. This move emphasizes the creativity required to develop good solutions to complex problems; the absence of formulaic approaches to design; and the role of intuition, sensation, and emotion in the evaluation and appreciation of engineering designs. The role of intuition is expressed in phrases such as "that looks about right" or "I have a feeling that this will work." The most important aesthetic value is simplicity--searching for the simplest means to accomplish the objective.

3. Think of ART in terms of engineering to emphasize the constraints materials impose on artists; the knowledge of technique and physical processes that artists must possess; and the role of practical considerations such as institutional and financial support. At its foundation, thinking of art in terms of engineering means recognizing that artists make design decisions within a set of practical constraints and with reference to a desired outcome or effect. This also entails recognizing that artistic artifacts are calculated to achieve an effect and do have a purpose.

4. Use the hierarchy of invention, design, and routine application to distinguish various levels of creativity and freedom within the two general categories of technology and art. Analysis using this hierarchy reveals the varying levels of creativity, skill, and social status within each category.

At the highest level, invention, none of the available solutions will solve the problem in question. New inventions are usually linked to what already exists, but they require a creative leap and tend to alter future practice. In order to be patented, an invention must meet the criterion of not having been obvious to someone skilled in the art. Design is the level at which most engineers work. It involves choosing from the options that are already known to work and deciding what to use and how to put it together. Because there are many workable solutions but only a few usually work well, intuitive evaluation is important for moving the process along efficiently. Routine application employs straightforward, standard solutions and is the level at which technicians are usually presumed to operate. In routine application, procedures are clearly and precisely defined and reliable step-by-step methods exist. Success typically depends on following instructions, and creativity is sometimes undesirable.

The three levels have correspondences in the fine arts. In the visual arts, we might conjecture that masterpieces and museum pieces constitute inventions. Like new literary genres or "great books," these works decisively shape future practice. At the design level, we might have portraits, book jackets, and original prints designed for mass production. Significant skill is required to create these kinds of art work, and they serve important commercial and social functions. Still, most are not products of exceptional insight or creativity, and they tend not to change the way we live or view the world. At the routine application level, we might identify products that can be created using standard computer graphics programs.

The point of the analysis is not to assign an artifact definitively to a particular level but to establish that in technology and in fine arts people exercise skill and generate products at all three levels. The analysis also raises some interesting questions. For example, what percentage of practitioners operate at each of the three levels in the respective arenas? How are engineers and artists rewarded for creativity? How do economic considerations enter into the various levels? What about skill and fundamental theoretical or scientific knowledge? Would it be fair to say that engineering places greatest emphasis on the design level while art gives most recognition to the invention level? These questions are important because engineering students frequently compare engineers working at the design level with artists working at or aspiring to the invention level.

THE VISITS TO THE MUSEUM

In the scheme outlined here, both visits to the museum require students to recognize the design decisions made by artists. The first visit emphasizes aesthetic responses to designed objects, while the second visit focuses on the ways design decisions reflect the designer and the culture from which the artifact originated. Interactivity is a crucial feature of the tours, which stress inquisitive looking and dealing with the material reality of the artifact. The people who conduct visitors through the museum are called “docents,” from the Latin *docere* “to teach,” because their job is not to interpret the work for visitors, but rather to teach them how to construct meaning from observations of the work. This approach emphasizes inquiry through visual examination.

In addition to being exposed through readings, lectures, and discussions to the ideas outlined above, the students are given a specific assignment associated with each tour. The students enter the museum with the kernel of a response to the artistic and aesthetic dimensions of a technological artifact. Their immersion in the museum environment and observation of artistic artifacts provide the stimulation to develop that kernel into a fully articulated aesthetic response.

First Visit: Analysis of Aesthetic Response to Designed Objects. As preparation, students are given this assignment: Before you visit the museum, you should identify some technological artifact to which you have a strong response and try to determine why you respond to the artifact as you do, During your first visit to the museum, identify an artistic artifact to which you have a strong response. Analyze the basis for that response and compare it to your response to the technological artifact.

The first visit provides students with their first directed practice in using the four conceptual tools described earlier in this paper, They learn to read the language of art, which means that they learn how to decode the information conveyed through the artists’ use of color, shape, line, texture, light, space, and other sensory aspects of objects. The docents use analogies drawn from engineering and mathematics and provide an atmosphere where students learn to support their own observations and trust their own opinions. In many ways, the process they go through resembles the gathering and interpretation of empirical evidence. The students’ judgments about what makes an artifact appealing necessarily involve holistic perception and evaluation. The docents help the students discern the design decisions that contribute to the viewer’s response.

One of the premises underlying this set of experiences is that the students react to visual images but rarely recognize the processes involved in their responses. Both the cultural meanings and the physical setting of the museum can help heighten the students’ awareness of visual stimuli and evocative power in artifacts. These sensibilities can then be transferred to the perception and appreciation of technical designs and artifacts.

In the discussions following the first visit, students mention a wide range of artistic artifacts along with a number of recurrent technological artifacts, such as the compact disk, which they admire for its combination of a shiny metallic finish and superior sound quality, or the automobile, whose aerodynamic lines reflect both scientific principle and high performance. They also may identify a wide range of factors that contribute to aesthetic appreciation including: form/function congruence, elegance and economy, order and simplicity, speed and power, size and scale, recognition/comprehension, capacity to operate on different levels, display of skill, intentional aesthetic appeal, and ability to revolutionize. It is interesting to consider which of these factors are brought into the discussion by the inclusion of technological as well as artistic artifacts.

Second Visit: Designed Objects as Expressions of Cultures and Designers. For the second visit, the students complete the following assignment: Identify a technological artifact that seems particularly expressive of either the person who created it or the culture in which it was created. While you are in the museum, identify a piece of art that seems to express its creator or culture particularly clearly. In each case, identify the expressive elements. Compare and contrast the two kinds of artifacts with respect to their expressiveness.

The students' responses to the first assignment provide a number of good examples of technological artifacts designed for everyday use that have significant aesthetic and expressive dimensions. The evolution of the telephone from a single black model through a limited range of colors and shapes, to the wide variety of colors, designs, shapes, and personal styles associated with it today offers a good example of the ways that aesthetic considerations can become prominent in the design of technological artifacts.

During the second tour, the students again gather visual information about artifacts, but this time the purpose is different: they are looking for ways in which the artifact expresses the culture, natural environment, and designer who originated it. Perceiving the expressiveness of artifacts means, to a great extent, understanding the information that artifacts carry. African art provides good material for this kind of analysis because it comes out of a significantly different cultural and natural context and because African ritual objects, which are designed for a particular use, have rich symbolic and aesthetic content as well. Once students recognize the expressiveness of artifacts from unfamiliar cultures, they should be in a better position to see the expressiveness of the technological artifacts produced in their own cultures.

Follow-Up Assignments. A number of written assignments can be used to follow up on the tours, to assist the students in articulating what they gain from the experiences in the museum, and to use the capacities for aesthetic and intuitive perception that they may have developed, They can be asked to write short essays recording their responses, to compose short stories about or conversations with characters in paintings, or to write poems about art work and compare the design process they used to write the poem with the process they use for engineering design.

KEYS TO SUCCESS

Museum Personnel. The most important prerequisite for success in providing these experiences for engineering students is museum personnel (education directors and docents) who rely on inquiry as a mode of teaching and who see themselves as "working to *enable* the students to participate in learning for themselves by beginning to understand visual information found in art."[10] Inquiry-based tours require extensive preparation and must be specifically developed to help engineering students experience technology as an art. The aim of the tours is *not* to enhance the students' capacity for art appreciation *per se* or to give them a particular view of the relationship of art and engineering but to enlarge their capacities for perception and criticism, especially in the visual and intuitive domains. This requires the docents to ask lots of open-ended questions, to develop an understanding of the basics of engineering design, and to act as catalysts between the visitor and the art.

Collaboration. The instructor organizing these experiences needs a reasonably complete grasp of both the technical and artistic aspects of a few artifacts that can be used as illustrative examples and points of departure. It is essential to draw on the expertise of museum personnel and engineering students. Building a full understanding of any artifact, whether technological or artistic, is necessarily a collaborative enterprise. And, like most productive collaborations, the one described here draws people into that sometimes uncomfortable zone where growth and learning are possible.

Recognition of Important Differences Between Engineering and Art. Students typically come into the study with definite ideas about significant differences between engineering and art; these ideas decisively influence the value and social status assigned to activities in each realm. Many proponents of the common culture of creativity overlook these differences. The historian Harry Eisenman, for example, in speaking of a sculpture, asserts that "*Only* [my italics] the final purpose of [the] work defines it as art rather than an industrial product created from a theoretical design. . . .The process was more important [than] the object."[11] To many--if not most--engineers, the final product and the reason it was created to begin with are not trivial or peripheral matters. Differences in purpose, motivation, and outcome matter a great deal, and they probably have to be dealt with directly in order for students to be able to validate the similarities that exist in the two fields.

THE PAYOFF

The tours and related assignments are designed to provide students with a perception-altering experience, not a body of information, A number of factors must come together for the experience to occur as intended, and not all of those can be controlled or measured. It seems reasonable to suggest, however, that students who experience technology as an art should enjoy a number of advantages in the practice of engineering and the appreciation of technology.

To begin with, they should find it easier to tap their capacity for visual and holistic perception and evaluation. These capacities are directly applicable in engineering design and are useful in a number of other contexts as well, especially when they are understood as complements to, not substitutes for, analytical and quantitative understanding. This should lead to a richer sense of the role of creativity and the potential for pleasure in engineering design, provide much needed motivation for engineering students, and set them on the path to greater lifelong satisfaction in their careers. It can also make it possible for them to integrate any artistic abilities or interests they possess into their professional lives.

Appreciating technical work as an expression of the individual who created it also encourages personal identification with work. Martin and Schinzinger, authors of *Ethics in Engineering,* assert that there is a positive correlation between personal identification and pleasure derived from one's work and the capacity to act ethically (i.e., to be socially responsible in the performance of that work). [12] One aim of the study of "The Engineer as Designer" is to help engineering students experience technical work in a way that connects that work both to their personal identity and to their social responsibilities. The premise is that people who understand the aesthetic and symbolic dimensions of their work are more likely to perceive its human and social significance and less likely to fall into the "technology as tool" mentality, which can lead them to overlook important ethical issues.

Understanding the evocative power of artifacts also provides insight into the ways that emotional appeals enter into the appreciation and evaluation of technological artifacts. Aesthetics can be an important part of marketing consumer technologies and also be essential in gaining public acceptance of many non-consumer technologies. We have a long cultural tradition in which positive aesthetic responses are associated with truth, beauty, and "the good." Still, as Arnold Pacey demonstrates in *The Culture of Technology,* aesthetic responses to technology can be misleading.[13] The aesthetic appeal of technology may arise from factors such as technical sweetness, the capacity to enlarge personal capabilities or to master elemental forces, the exhilaration provided by speed and power, the display of skill, scale and size, or association with adventure. These factors can make a technology appealing, even when the technology in question does little or nothing to meet important human needs and may have negative impacts, Students who understand the evocative power of artifacts are in a better position both to use that power to advantage and to recognize when it is misleading or misused.

Thus, engineering students who experience technology as an art should possess a richer view of technology, an expanded capacity to learn by looking, and a greater awareness of the factors involved in successful engineering design, They should also be better able to appreciate the pleasures engineering design offers.

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