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**POSITION PAPER**

# The future of computers and the teaching of engineering design

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## 1. WHERE WE ARE TODAY

I would like to begin with a list of some of the things that are happening today in the arena of engineering design and how it is to be taught:

### 1.1. Virtual university

In some of the midwestern states, programs are now under way to make a university education available to everyone at a modest cost using the web. The example sometimes cited has someone who wants to learn the computer language C++ doing so at his or her leisure at home using the web. If this person can learn computer programming at home, then what about the other courses that comprise a university education? The virtual university is a particularly interesting idea to a school like New Jersey Institute of Technology (NJIT), where we offer a part-time evening program under which the student forgoes much of what is thought to be university life.

The implications of the virtual university are dramatic. Will there only be one or two people in the whole world concerned with the teaching of C++ in this new environment? (Parenthetically, what will the rest of us do?) Is a high-quality automated presentation better than some of the sloppy things now served up manually to students? What are the limits of this type of activity? Is there anything in the world of teaching that cannot be automated? What is the difference between training and other types of learning? Is there anything good about a classroom environment that is lost over the web?

### 1.2. Engineering design

This symposium is set up to link engineering design and the computer. Is this a natural linkage? Because this position paper is to be academic in nature, what is it we do when we teach engineering design? In fact is it possible to teach engineering design or should that be left to industry? What should be taught under the aegis of engineering design?

The past 30 years or so have shown us several things:

1. *You don't have to know what is in a computer program to use it.* In industry it is now common for engineers to use computer programs that they do not understand. In fact, this would appear to be the rule rather than the exception. Still, how far should this go? If a specific type of design is completely automated, is it enough to have a secretary push the button to turn on the computer to generate the design?
2. *Design is a commodity.* This was proclaimed on the cover of a recent edition of *Engineering News Record.* Then who is to own design? If you need to build something, do you shop around the world to see whose computer program is the least expensive? (We now commonly shop drafting and computer programming around the world in exactly this manner.)
3. *If it can be automated it will be automated.* We all have examples of facets of the world of design that have been completely automated. In civil engineering, the first to be automated was probably highway cut-and-fill calculations. These days, the design of simple industrial buildings, most analysis, short span bridges, design of structural elements, . . . are all highly automated. In aerospace, there is the truly frightening example of the highly automated design of a new transport without the help of physical testing.

### 1.3. Role of NSF-sponsored coalitions

While the virtual university may still be only a dream, there are many design applications now available on the web. The National Science Foundation (NSF)-sponsored Gateway

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coalition, for example, now has educational modules available on the web. In the structures area, these include a fabric structures module that now resides at NJIT and some architectural modules that reside at Columbia University. In these cases, the point is simply to make course material available so that it does not have to be repeatedly generated. The result could be that if these modules are continuously updated, high quality educational materials will be developed and made generally available. If high-quality educational material becomes available on the web, it will, of course, matter less and less where the student resides. Why then, for example, pay the high fees at Massachusetts Institute of Technology (MIT) if a comparable education is available for less at NJIT?

One point is certainly clear with regard to the web and engineering design. Both the teaching of engineering design and its practice rely heavily upon the use of examples. Even in its present state, the web makes available enormous amounts of information. The designer and the student can expect that their design world will soon be much different than it has been in the past.

The Gateway Coalition has done other things. For several years, it has supported the teaching of engineering design to freshmen. It has argued that conceptual design is a top-down process which it is not necessary to have sophisticated engineering skills to understand, at least in the beginning. The Gateway Coalition has also supported the use of ISDN phone lines, which allow the sharing of teaching resources. In this manner, when teaching design you can access the skills of some distant expert whom you might not be able to afford on a full-time basis.

### 1.4. Softening the discussion

There is a strong sense about these days that the approach used to discuss topics such as conceptual design must be broadened. This idea traces back to Godel, or at least to Zadeh, and engineering designers have seen it in the inability of mathematical programming to completely formalize engineering design. But the changes in thinking seem to be pervasive: attempted precision in law making simply leads to loopholes, decision theory now has its naturalistic approach, and perhaps, best of all, there is Zeleny's Tradeoff (Smithson, 1989), which says that we have the choice of being either vague or wrong.

## 2. THE FUTURE

Having discussed the chaos of the present in the first part of this paper, I would like to focus for a moment upon the opportunities now available to the engineering community. The computer has truly changed the face of engineering design and it has done so during the lifetime of the older engineers at this symposium. Re-engineering is now the buzz word. The up side of re-engineering is that it gives us the opportunity to rethink what we are doing. We need to decide what it means to teach design. It seems to me that the difference between routine design and conceptual design is of primary importance. At its best, conceptual design deals with building things that have not been built before. This places designers beside creative artists and gives more meaning to questions of how design should be taught. In fact, we probably don't even know how to teach conceptual (creative) design, but the discussion of it gives focus to the idea of the tools and skills required to do so. Engineering designers must be taught certain skills because engineers are defined by what they can do in some technical sense. More to the point of this symposium, one of the few things that can be done to support creative designers is to provide a good working environment for them. That is, if you wish to produce good engineering designers, you should make available to them the best engineering technology in terms of computer hardware and software. That seems to me to be the main point for all design centers in engineering education, at Harvey Mudd College as at all other schools of engineering.

## REFERENCE

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**William Spillers** is a structural engineer by trade with B.S./M.S. degrees from Berkeley in Civil Engineering in 1955–1956. After working briefly in San Francisco, he returned to school going to Columbia University where he worked in continuum mechanics under A.M. Freudenthal and received a Ph.D. in 1961. In 1975 he left Columbia for Rensselaer Polytechnic Institute; in 1990 he moved to the New Jersey Institute of Technology where he is a distinguished professor of Civil and Environmental Engineering and chair of the department. Spillers' career has revolved about structural engineering where he has moved from *Automated Structural Analysis* (Pergamon Press, 1972) to optimal design (*Iterative Structural Design*, N. Holland, 1975), and to nonlinear structural analysis (*Analysis of Geometrically Nonlinear Structures*, Chapman & Hall, 1994, with R. Levy). This has allowed him to become involved with major structures such as the John Hancock Building in Chicago. During this period, he also worked with David Geiger and Horst Berger helping to develop the contemporary field of fabric structures. In 1974 Sillers organized NSF's first effort in the area of design theory (*Basic Questions of Design Theory*, N. Holland), which in turn fostered in him a lifelong interest in the formal aspects of engineering design. Presently, he is concerned with the role of ambiguity in design theory.

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