ENGINEERING AT THE COLLEGE LEVEL

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USING THE QUALITATIVE MODELING TECHNIQUES OF ARTIFICIAL INTELLIGENCE PROGRAMMING, IT IS NOW POSSIBLE TO TEACH HIGH SCHOOL AND UNDERGRADUATE, NON-ENGINEERING MAJORS ABOUT THE DIFFERENT ENGINEERING DISCIPLINES AND WHAT ENGINEERS DO, WITHOUT REQUIRING A BACKGROUND IN CALCULUS OR ADVANCED PHYSICS.

A recent PhD graduate in Computer Science from Stanford does not know that civil engineers design buildings. A physics student at a California state university solves "crane and boom" problems, without learning that actual construction cranes use counterweights. A novice *Time Magazine* reporter, fresh with a BA in English, struggles to understand how JPL scientists reprogrammed Voyager's cameras to pan the planet Neptune without breaking the signal back to Earth. These and countless examples anyone can recount from personal experience reveal a classic and increasingly serious split between humanities-science disciplines and the practice of engineering. We are not enticing enough good students into engineering. We are not providing the tools the rest of the workforce needs to understand and relate to what engineers produce. We are not giving the populace the intellectual background they need to participate in political discussions about the use of nuclear power, space exploration, or medical research.

The problem is manifested most seriously in the relative loss of American economic power over recent decades, as foreign engineers, notably the Japanese, perfect and successfully market our technical innovations. An often-cited example is the loss of the entire VCR industry to Japan, despite its invention and early development in the United States. Certainly a variety of interacting factors, including dismal consumer marketing and cowardly business leadership, contributes to the loss of American technological prowess. However, a significant part of the blame falls on outdated and unmotivated education curricula. Despite a two-fold difference in student populations, nearly as many Japanese as American engineers graduate each year (Science, August 11, 1989). And although America continues to demonstrate a significant lead in basic biology and physics discoveries, it is Japanese scientists who realize the practical application of these discoveries in fields as diverse as pharmaceuticals, photography, and automotive engineering. The recent spurt of Japanese activity in superconductivity continues their emphasis on materials science, adopting an engineering perspective which translates basic scientific principles into commercial products.

With the advent of the qualitative modeling techniques developed in artificial intelligence programming, we have the opportunity to, at the very least, expose students to the domains of engineering disciplines, and to excite them about the lively combination of design crafts and analysis of the engineering process. New representational techniques, combined with personal computer color graphics, revolutionize what we can show and discuss with students who have minimal science background. Indeed, we can and should turn the current curriculum on its head, placing calculus and advanced sciences after introductory engineering. Physics, advanced chemistry and biology could be opened for far more students if they were taught in the context of manufacturing, drug therapy, or satellite image processing. In essence, we can and should quit force-feeding students dry, decontextualized theories, and start instead with living, vibrant, visible examples such as the closing of Ford plant down the street, newspaper arguments about how much a drug company should charge for AZT, and whether the Galileo space probe should be launched with a nuclear power plant over central Florida.

For example, taking an expert system like SACON, we can allow students to construct different buildings, experimenting with proportions, support structures, and materials, to learn the basic trade-offs of cost and risk in structural engineering. Motivating examples can be easily supplied from the daily press (e.g., an LA hospital in the 1975 quake, the St. Louis Hyatt's suspended walkway, the bulkhead failure that cut the control lines on the Japanese Boeing 747). A graphic tool kit would enable creative, individual construction, automated analysis of stress and deflection behaviors under student-designed loads (e.g., a earthquake, fatigue from repeated use). A computer coach could help the student explore the space of alternative designs. Scoring and competitions would allow students to realize the relative merits of their solutions, as well as introducing appropriate elements of financial and dynamic realism (e.g., including the projected lifetime of a structure and operating cost). A suite of such design kits would introduce students to fields as diverse as environmental engineering (e.g., smokestack scrubbers and sewage treatment), energy production (e.g., exploring alternative designs of solar, coal, or nuclear power plants or how oil is transported from Alaska), city planning (e.g., simulating traffic flow and the effects of greenspace on sightlines or smog formation), and disease treatment (e.g., the effects of different drugs on AIDS, Alzheimer's, and Parkinson's). All of this would be built upon the qualitative modeling methods of AI programming, integrating graphic depictions of structures and processes with numeric simulations. Linked modules would take the student into explorations of more basic laws, notations, and experimental methods of science, which remain historically rooted to the context of well-known technological marvels and social/environmental dilemmas and disasters.

The student is thus placed in realistic situations that motivate an understanding of basic science and mathematics. But perhaps most importantly, these kits engage the student in thinking about the need for and limitations of technological solutions in a social context. In essence, we are enabling the student to become a citizen who will be able to intelligently participate in discussions about how tax dollars get spent for servicing and changing a community. In addition, we can hope that the early introduction of an engineering orientation will better motivate the study of science and mathematics, stimulating more students to choose an engineering career.