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The Computational World [1]

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I would like to develop an undergraduate-level course that helps students not only to develop a basic understanding of computational ideas, but also to situate those ideas within a broader portrait of modern scholarship. This course, tentatively titled "The Computational World," would focus not on particular applications (spreadsheets, word processors, and so forth) nor even on isolated "skills" (e.g., how to write a program with a loop inside it), but rather on the ways in which computers have impacted scientific and artistic thinking.

The course would likely include topics such as:

a. the role of simulation as a source of experiments in science and mathematics;
b. basic ideas of algorithms and their representation;
c. the notion of a "language" or notation for communication procedural ideas, as an artifact of design in its own right;
d. computational models of mind, and how they have affected the study of vision, language, and creativity;
e. "emergence" in computation and how computational models enable us to create many complex systems as a collection of myriad simpler, interactive entities;
f. the notion of "information" as an object of study.

To my knowledge, there is no undergraduate course quite like this in existence, and I would like to accompany the development of the course with both innovative laboratory materials and a textbook to encourage the creation of other courses in this genre elsewhere. More generally, I would like to use this course and its development as a springboard for promoting and encouraging interdisciplinary collaborations for students and faculty in computer science.

Design-Oriented Courses: Blending Theory with Physical Fabrication

During the current semester, I have been teaching a section of GEEN (General Engineering) 1400, a course primarily for first-year and incoming engineering students. My section of the course, offered for the first time this year, focuses on the engineering of Leonardo da Vinci; the students explore da Vinci's notebooks and then use a variety of novel fabrication tools in our lab to recreate his brilliant designs. For the students, this curriculum provides an encounter with the (often-neglected) historical and biographical elements of engineering- Leonardo is an irresistibly fascinating personality and the Renaissance, a golden era of early engineering. At the same time, however, the students employ state-of-the-art devices and computational techniques as a means of rethinking this beautiful tradition of engineering. Our lab is equipped with both a computer-controlled 3D prototyper and laser cutter, as well as a variety of traditional machine tools. It should be mentioned that the GEEN 1400 students are currently, as of this writing, working on their still-unfinished larger-scale final projects.

I would like to extend the basic theme behind this course in several potentially exciting directions. One possibility would be to design a more general course in the history of engineering, integrating elements of design and historical study. Such a course could involve students in the recreation of important ideas in the history of technology - e.g., in the use of waterpower, the design of clockwork, the manufacture of textiles and paper, and so forth. (I have recently submitted a proposal to the National Science Foundation suggesting course development of this sort of engineering.) Other possibilities might incorporate design and fabrication into the study of science and mathematics: for example, a curriculum in the design and recreation of important historical scientific instruments, or a course focused on the creation of small-scale scientific instruments for home or amateur use; or a course on the design of mathematical puzzles and games (e.g., topological puzzles), or mathematical artwork more generally. One particularly interesting avenue that I would like to pursue, would be a collaboration with students or faculty in psychology and the fine arts, focusing on the design and creation of physical artifacts that creatively represent optical illusions and other interesting visual phenomena.

Essentially, then, the larger agenda that I would like to pursue is one in which engineering and design are integrated with more traditionally "theoretical" study. Indeed, the time is right for this sort of integration, given the advent of powerful new design software and computer-controlled fabrication tools. Rather than viewing computers as abstract desktop devices, we can instead begin to view them as the centerpieces of a new sort of "shop"; and I believe that this new view of computers can have tremendously innovative and important education consequences.

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