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POSITION PAPER

Computers and learning

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Abstract

The important questions for instructors to address concern what skills the student is to learn and how the student is to be motivated to acquire those skills. Questions about simulations, graphics tools, and the like are unimportant until the first two questions have been answered adequately. We discuss the role of explanation by students and describe a mechanism for motivating students to learn.

Keywords: Learning; Goal-based Scenario

Why are you asking about "computers in learning"? What do you mean by "learning"—what, to you, would be evidence that somebody had "learned"? What do you want them to learn? We think the first question should be the last to be addressed, but it is a very interesting one.

Somebody has learned something if she can explain it to someone else, or if she can do that which she was to learn. To us, this suggests that learning comes from doing, from active engagement with the material. And it suggests that the act of explanation by the student is an important tool in learning. We believe that to such an extent that one of us has taught a course in which students took their exams (including both open- and closed-book exams) in pairs, allowing them sufficient time so that each member of a pair could try to explain the relevant material to the other. Later we can consider possible roles for computers in helping students explain things to other students.

You will probably argue that there is some "body of knowledge" that a student must "learn" to become an engineer. As biologists, we can not really argue with such a proposition, although we would love to. But we bet you believe in a larger body of knowledge than really is necessary. We do believe that your students need to acquire skills; accordingly, we believe that one of your most important jobs in teaching engineering design is to identify the skills your students really need to learn. (We bet that does not include solving integrals by methods other than numerical, for example.) One of the skills a student needs to acquire is the skill of learning itself—she needs to learn how to learn. You can certainly identify crucial skills required in the process of engineering design. And we can consider possible roles for computers in helping students acquire these necessary skills.

The least satisfactory way to learn skills is to attend a lecture—this is an utterly passive experience. Another unsatisfactory way is to read through assigned chapters in a textbook—except for the skilled learner this, too, is too passive. Most textbooks are best used as reference books for students actively seeking specific information in pursuit of a project. Of course, instruction in engineering/science institutions features lots and lots of problem solving. What a great way to learn to do something, right? Or is it? This depends entirely on the student's motivation. In our opinion, heavy problem solving, via homework, is not usually as productive as engineering and science faculty believe. For some students (the ones who most commonly become faculty members themselves) such assignments are sufficient motivation in themselves (as are reading assignments and, may heaven help us, lectures). But those of us in this room are not the problem we seek to address.

So what can computers be used for in light of the claims we have just made? How can they produce real learning (an ability to do or to explain) where lectures and even assigned problems may not? How can they help a student acquire skills? Can a computer be used to motivate students to

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learn? We had better start with the last question, because it is the key to the others.

Almost everybody in this workshop came here with simulations firmly in mind. We do not have to sell you on the idea that simulations are potentially useful in technical education of all sorts. But we need to ask you to consider whether simulations produce learning in otherwise unmotivated students. We agree with those who will point out that computer-driven instruments and computerized data acquisition are irreplaceable—but our question is whether students learn from them, and specifically whether they learn the target skills as effectively as they might. We think that you are lucky to be concerned with engineering design. If ever there was a field that lends itself to motivation via computers, this is it. Why?

The student will learn something best (and, we are tempted to say, only) when she seeks it out herself in service of a task she has decided to pursue. The task of getting great grades is the task of a budding faculty member—a nerd. For more normal folks, we require better motivation. The most appealing avenue we have ever studied is what Roger Schank calls a "goal-based scenario" (GBS). Some GBSs are games, pure and simple, but with serious content. The student pretends to be somebody with an interesting job, confronted with a challenging but interesting problem.

In an art history or art appreciation course, an example GBS would invite the student to be a museum curator trying to determine whether a newly discovered painting is a Rembrandt. A student buying into this scenario would need to seek out information about the development of European art and would surely pay closer attention to known works by Rembrandt and his contemporaries than would a student pursuing a conventional learning activity. Schank's group has developed a GBS called "Sickle Cell Counselor" that is on display at the Chicago Museum of Science and Industry. The visitor is invited to advise one of three young couples, in each of which at least one partner has sickle cell disease or is a carrier, about the wisdom of having a child. To provide reasonable advice, the visitor finds it necessary to learn about Mendelian genetics, electrophoresis, red blood cells, and medical aspects of the disease. This interactive exhibit has attracted thousands of visitors. As a final example of a GBS, picture yourself as an intergalactic explorer racing the clock to determine which type of medication to give your partner, who has just been felled by a toxin-tipped dart. You will certainly need to learn a fair amount of neurobiology, including synaptic transmission and action potentials—both of them topics that many students find forbidding in a conventional course setting but that become manageable if the student is the one deciding it is time to learn them.

Consider having students prepare GBSs for each other. Consider having pairs of students prepare GBSs for other pairs. Can you set design solutions in cooperation or competition with one another—either interactively (two teams drilling a tunnel from opposite ends) or in independent runs (delivery systems vying in terms of speed, accuracy, cost; structures to achieve goals at minimal cost)—in such a way that the computer, rather than you, determines a winner? Is it appropriate in your course that there be a winner?

The point of all this is that you need to be asking and solving the right questions. Neat simulations, high-powered graphic tools, and the like are not where to start determining the roles of computers in learning. They are among the end tools. They become your concern only after you have determined what is really to be learned and how that learning is to be motivated.

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