The Multi-Modality Interactive Computer Tutor: A Proposal to Help "Equalize" Students with Varying Backgrounds in Science

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COMPUTER TECHNOLOGY ALLOWS knowledge to be presented in a manner that teaches using all the senses and involves the student in the process. This technology should benefit the teaching of science, especially to students who have trouble grasping the imagery of abstract models with which scientists view the world.

Introduction

Advancing technology presents us with challenges as well as opportunities. The pace of technology has been such that in just over one generation, we have developed and popularized communication tools such as computers, satellites, fiber optic broad band, and now the Internet. Progress in technology has led to increased requirements for both basic science education and specialized technical education. It has forced many who thought they were finished with their education to continuously update their expertise or to move into fields that may not have existed when they were in school. It has also required the public to be better informed about the ways and language of science, since in our society the public is called on to be involved in decision making through the democratic process. One needs to look only at the news of environmental problems occurring in the defunct Soviet Union to see the consequences of technologically uninformed persons making decisions about the applications of technology.

Role for New Technology

The new technology also brings new tools to the learning process. The multimodality interactive computer tutor can be such a tool. The use of computers in teaching technology has usually focused on providing a means for drilling the student. But computers can also be used to actually present ideas and teach approaches to thinking in ways that are more visual, alive, and attention-holding than what can be accomplished with a printed textbook and, in some cases, even the classroom.

The challenge to teaching technology is to teach thinking that can focus on a problem, abstract the important properties of a problem, and provide a manageable model of the problem that is within the possibility of solution. Such thinking can benefit the student even if the student does not become a scientist. Such thinking makes it possible, with the aid of precise analysis and precise communication, to uncover the parts of the problem that were solved in the past and to apply the tools of logic, analytical thinking, and careful observation to obtain a new solution.

These abilities do not come with equal ease to all. Some students catch on to this process more easily than others. The teaching of science to non-science majors attempts to expose these students to the development of the scientific method and to demonstrate it with simple examples. It is hoped that in the process they can come to an appreciation of the power of this "scientific" thinking, begin to understand its strengths and weaknesses, and learn how it must be applied to further our knowledge about problems.

However, students have different backgrounds. Some are able to engage in abstract thinking more easily than others. Others even fail to realize the reasons for being exposed to scientific thinking. They think the exercises they are asked to perform are at best trivial and at worst useless. It is the goal of the "Equalizer" project to try level the field for students of different backgrounds. Success at communicating to non-science students the real reasons for studying science should at the least help with student motivation and lower their attitudinal barriers to being exposed to this learning process. The project provides simple participatory exercises that involve basic science tools as abstractions of the properties of the real world, careful and objective observations and measurements, mathematics as a model, and explanations and extrapolations of conclusions reached from scientific observations. The assumption is that some students can best learn from these exercises in a self-paced, interactive environment, that is rich in stimuli of all the senses. These exercises should help these students with their work and understanding in a traditional science course.

The Multimodality Interactive Computer Tutor

Normally, a textbook is used to supplement the instructor's classroom teaching. Therefore, it may be of use to list some of the advantages of the computer

tutor over the textbook, especially as these apply to teaching science to non-science majors:

The non-science major laboratory experience can be made less frustrating and more understandable with computer simulations. It is not unusual to encounter students who understand the point of the laboratory only after it is over, when they discover the steps they should have performed but did not. It is also not uncommon to find students becoming so bogged down in the mechanics of an experiment that the lesson they are to learn becomes obscured by the details of the measurements. The ability to simulate the experiment should allow a dry run at with the opportunity to discover all the factors that are important when carrying out the experiment itself and to better grasp its purpose.

A Step Forward

If we look at education as transmission of knowledge, we can see that it was always influenced heavily by technological progress. Education started with the teacher who was both a role model and a source of specialized knowledge. Initially, this source was helped with the recall of knowledge through stories as well as other mnemonic devices. When the written word became available, it took on a large role in teaching. The advent of the printing press was welcomed since it allowed this word to reach larger audiences. Illustrations and photographs found their way into books as soon as the technology became available. Since animated graphics, movies, and sound required physical media other than paper, they could not be included in the textbook but became supplements to the textbook. With the development of the computer, all these modalities can co-exist within the same medium. It is inevitable that this new medium will usurp the place of other sources of knowledge in many areas of learning, as soon as the computer becomes universally accessible.

The new communication technology allows access to larger audiences and a wider dissemination of knowledge. There are some caveats. The learning process should be fun, but the computer is, after all, a machine and interactions with machines can be often frustrating. Computer games have already shown our students that computers can be fun. As soon as such effort is dedicated to developing user-friendly educational software as is already dedicated to games, the educational programs may wind up having as much attraction for students as games do. What about the teacher? As responsibility to teach more students increases, the teacher is pushed into greater isolation, teaching more and larger classes. With the computer as an expert aide, even co-worker, the teacher would find that some of the burden of teaching can be borne by machines while the teacher can return to a more participatory and satisfying role in the classroom with better prepared and hopefully better motivated students.

Traditional Textbook vs. Computer Textbook

Traditional Textbook	Computer Textbook
Static illustrations	Dynamic illustrations with verbal and visual explanations
Illustrations and text often disconnected	Animated illustrations and verbal explanations concurrent
Formulas and graphs with printed explanations elsewhere on the page	Actively developing and changing formulas with concurrent graphs, illustrations, annotations, and verbal explanations of what these represent
Textual summaries at the end or beginning of each section and an index and glossary in the back of the book	Text summaries, index, and key word definitions just a click away (can be made to overlay the material temporarily, then the student is back in the lesson)
Very flexible continue, jump-to, and review options	Continue, jump-to, and review options are set at predetermined points (this reduced flexibility is offset by the possibility of less intrusive changes and better controlled continuity of presentation)
Predetermined navigational aids (book divisions and their headings)	Predetermined and interactive navigational aids include help screens
Testing is always separate from the learning process and determination of student effort can only be made by inference	Testing is concurrent, student feedback is immediate, and tracking of student progress through the material can be included
Lab exercises require separate activity with the book supplying at best equipment drawings and "cookbook" descriptions	Lab descriptions can include equipment simulations and active student participation in non-destructive trial and error

Conclusions

In summary, textbooks provide the students with a passive learning environment. The computer tutor is able to provide a learning environment that is active and participatory. It more resembles lectures, without the option to ask questions, though questions can be included in the computer tutor if they are anticipated. The computer tutor environment may certainly be as effective as that provided by lecture courses where the class size is very large.

A large class size is often found in beginning classes, which often are attended by students with varying backgrounds and students from several disciplines. The stu-

dents in such classes are probably those who would benefit from individualized attention, which is impossible because of the large class size. Many of these students are more likely to be left behind and not get as much as they can out of the course. At least with the computer tutor, the students who may be slower at grasping necessary key concepts can spend as much time as necessary at their own pace with the "tutor" until they have attained a reasonable degree of understanding of the material.

The obvious advantage of self paced-computer learning is that it allows the student to set a pace consistent with the student's background. However, there are other advantages. Self-paced learning helps insure the continuity of material presentation. Continuity is especially important in science since science is a structure that builds steadily on the base of previous achievements. Self-paced learning assures that the student does not need to race on ahead with the class and skip over material that may not be clear at the time.

If one assumes adequate student access to computers, this type of learning also allows efficient and flexible use of student time, as well as efficient use of teaching personnel. Once the students have been "equalized," teachers would be working with a more homogeneous class. Teachers would need less time to bring everyone to a level of minimum understanding. They would also be able to spend time on more advanced concepts and not worry about leaving behind large segments of the class.

Our experience with a computer tutor is based on a module, "The Nuclear Imaging Tutor" (Eubig et. al., 1994 and Eubig, 1996), written in Authorware Professional (Macromedia, San Francisco, CA) and used in the Radiology Department at the Medical College of Georgia. Authorware was chosen as the authoring program because it allows easy import of graphics, sound, and movies into the presentation. It provides the ability to easily annotate and move objects, create simple graphics, and interact with the student. Authorware allows smooth execution of a finished program from the CD, cross-platform transferability (Macintosh and PC), and the ability to put the finished module on the Internet. This last feature has future application for providing long distance education and continuing medical education, which can easily be kept current. The Nuclear Imaging Tutor has been used by Nuclear Medicine Technology students, Nuclear Cardiology fellows, and Radiology residents. The fact that this module could be used at times of the students' own choosing was important to the post-graduate students. The evaluation of this module is primarily anecdotal. However, numerous student comments indicated that, because of the vivid graphics, students were able to understand for the first time physical and mathematical concepts that they had read about but could not grasp before. The module also met with favorable comments from peers and a number of awards when exhibited at meetings (Eubig et. al. 1993 and Eubig et. al. 1994).

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Casimir Eubig is a Regents' Connecting Teachers and Technology Faculty Development Workshop award recipient.