The New Wave of Educational Software. (Guest Editorial)


**Introduction**

Explorations of the computer as a tool to help students learn have been going on for about a quarter of a century. During most of that time most of the energy expended has been focused on pre-college students. Probably 90 percent of the available educational software addresses this group of students.

During this same period, there has been a great deal of research on the computer's effect on rate of learning and retention of learned material. In both areas, the computer has had a dramatically positive effect, even though almost all of the research has focused on drill and practice applications. There also have been small efforts to assess the impact of learning to program a computer on the development of problem-solving ability, and the effective use of simulations-again with positive results. Despite these very positive research results, we have only begun to realize the computer's potential to help students. There are two reasons for this long gestation period:

- Until recently, computers were sufficiently costly that they were available to students only on a limited basis; and
- Only during the past three to five years have we learned enough about the development of creative learning environments to take advantage of the computer's great potential.

Until three years ago, most of the applications of computers in education consisted of teaching programming, or using drill and practice programs to teach facts. Recently there has been an exciting new wave of educational software, which I address here.

I wish to outline briefly some of the exciting ways in which this new wave permits the teacher to use the computer to improve the learning environments of students-ways which will make it easier for students to learn, more exciting for them to continue in the learning process, and more successful in pursuit of their goals.

**The New Wave**

The new wave of educational computing includes:

**Learning to Write Well**

Word processors, spelling checkers, outline generators, grammar and style analyzers and pre-writing guides will take much of the chore out of writing, permitting the student to concentrate on the creative part of writing, rather than the mechanics.

**Discovery Learning**

Since the early days of the Huntington Computer Project, it has been clear that the computer has a great deal to offer to educators as a flexible universe within which a "world" can be created with any set of characteristics desired. Simulations in the natural and social sciences have
provided students with opportunities for experiential learning which are unavailable otherwise. There have been applications in biology, chemistry, engineering, ergonomics, physics, physiology and psychology to name just a few.

In each of these fields, the teacher can create situations which conform to the normal laws of the universe (or to some subset-e.g., permitting the suspension of randomness), or if it is desirable pedagogically, which defy them. Students may be given control over system parameters so that they can explore their effects. Research has shown that this is very beneficial to students.

Relatively little work has been done exploring the effect of discovery learning in mathematics; however, this aspect offers much promise in enhancing students' understanding of mathematical concepts in algebra, calculus, statistics and probability, finite mathematics, etc.

For the first time, teachers of mathematics have available meaningful laboratory experiences for their students. Here, the student can discover and comprehend mathematical relationships and properties of mathematical functions in ways which have not been possible before. This appears to be especially valuable as a learning environment for students who have not succeeded in mathematics taught in conventional ways.

The relatively good graphics available on modern microcomputers have permitted dramatic improvements in the creation of discovery-learning environments in all disciplines.

**Construction Sets**

The construction set is a newcomer to the education scene. In such programs the user has a free-form environment with a set of objects which may be used to build simple universes. In the broadest sense, the construction set is a special-purpose language which permits the user to create complex effects without having to learn to program in BASIC, Pascal or machine language.

Rather than attempt to define construction sets in words, it seems best to define them by example. Some of the best of the currently available ones are:

- Rocky's Boots and its sequel Robot Odyssey I by The Learning Company provide the user with sets of pieces (including wires, AND, OR and NOT gates, actuators and sensors) from which rather complex logic circuits, and even large integrated circuits, may be constructed by unsophisticated users. These circuits are used in conjunction with sensors to control a set of actuators. Rocky's Boots was the first construction set to reach the market, although when it appeared the term was not in vogue.
- With the Pinball Construction Set by Bill Budge, the user is able to define a pinball machine by specifying how many bumpers, flippers, etc., there will be, and where they should be placed. Further, the user may specify the characteristics of the bumpers and the balls, so that varying amounts of energy are absorbed. It is possible to imagine a lot of good physics being displayed in this "world."
- Music Construction Set permits the user to "construct" a musical piece by arranging notes on a staff on the screen, and then specifying the characteristics of the instruments which will play the music.
- In The Factory by Sunburst the user can choose up to eight machines from an array which includes punch presses, rotating machines and paint striping machines. The
user decides what the characteristics of the finished piece are and then selects the specific machines to use and their sequence to create the piece.

- **Just Imagine!** by Commodore permits the user to create stories which include background scenes, fixed objects (e.g., a gorilla), animated objects (e.g., a scuba diver) and the trajectory of each animated object, plus a 20-line story. When the user is finished, s/he can play the entire story back and enjoy an animated scene with background music and a story which scrolls onto the screen.

- **Dream House** by Joyce Hakansson Associates permits the user to take a bare house and choose colors to paint the walls, floors, ceilings and cabinets, then choose and arrange furniture in each room of the house. The user is also permitted to arrange trees, shrubs and flowers outside the house. Some of the objects (e.g., a flowing fountain or a canary) may be animated.

- **KoalaPad, Graphics Magician, Sorcerer's Apprentice, etc.,** permit construction of graphic images from lines, rectangles, circles, etc. They also permit the creation of complex graphic images in full color, without the difficulties usually associated with drawing.

- **The Adventure Construction Set** by Electronic Arts lets you build your own adventure game using up to 500 characters, 250 settings ranging from the medieval era to science fiction, 30 sound effects, graphics and a variety of items including weapons, magical items and furnishings.

It is becoming clear that creative software developers can generate worlds in which exciting things will happen to students—assuming that construction set developers include creation of learning environments among their design goals. Most of the existing construction sets have as their motivation the generation of income (a worthwhile objective, if education is another), although some (most notably Rocky's Boots) were developed principally for education.

Some new construction sets I'd like to see are:

- A chemistry construction set which permits the user to build ionic and non-ionic compounds by arranging molecules in groups.
- A geometry construction set which contains lines, circles, ellipses, etc., to build geometric figures.
- A physics construction set to permit construction of experiments and physical worlds as the user desires them, with parametric values up to the user's discretion.
- Structures engineering sets to permit the building of structures with variable loading.
- A vector construction set which permits construction of vectors composed of several component vectors which may be added together algebraically. After the construction is complete, the computer should decompose the resultant and component vectors into horizontal and vertical components. The ability to rotate the entire set of vectors would also be desirable.
- Electric and magnetic-field construction sets within which the user can create configurations of charges (or poles) and establish boundary conditions.

**Adventure Games**

Adventure games have tremendous potential for developing skills in reading, comprehension, decision making, problem solving and information processing. Unfortunately, most of the commercially available adventure games have been designed to be commercial successes, rather
than good educational tools. As a consequence, they have an unfortunate shoot-em-up, blow-em-up quality which turns off some students (most notably females), and which contributes little to the learning environment. It is possible to design such games so that they take advantage of the format and excellent parsers appearing on the market and still incorporate educational goals including appropriate vocabulary levels, sentence structure, story lines and graphics.

**Laboratory Support**

Modern microcomputers, combined with inexpensive microelectronic circuits (e.g., analog-digital converters), provide teachers with a new laboratory tool which permits substantial improvement in the students’ experiences in gathering, digesting and displaying experimental data. It is now possible to combine an inexpensive computer with a low cost A/D converter to create a super-oscilloscope which gathers data, then processes them using statistical routines and displays the results graphically. This experience now is useful even with students who have little or no background in statistics (the technique has been used successfully with sixth graders).

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**Telecommunications**

Because of the development of low cost modems, communications software, and national telecommunications networks, it now is possible to think in terms of providing students with access to powerful systems for communication with each other, with their teachers, with experts in any field, and with elaborate data bases. Such access permits students to participate in courses and other learning experiences, even if they are remote from the campus at which they are enrolled. Perhaps more importantly, the communication is asynchronous; it doesn't require users to be at the same place at the same time. This allows the student easy access to the teacher without regard to the schedules of the student or the faculty person, and without regard to the location of either. For the student with a difficult schedule (e.g., a student who travels a great deal), or for the student in a remote location, or for the student on campus whose schedule doesn't overlap that of the faculty person, telecommunications, properly applied, can be a good solution.

**Tools**

 Probably the most important development in academic computing in the past five years is the emergence of tools-programs which convert the computer into a tool to carry out some job. We already have mentioned several tools above, including word processors, construction sets, telecommunications and laboratory-support systems. There are several others, among which the most important may be spreadsheet and data base programs.

Spreadsheet programs have become very popular over the past several years after the first, VisiCalc, was developed as a tool for financial analysts. They were developed around the conventional accountant's spreadsheet and permit the user to specify equations involved in developing financial statements. The operations specified by the equations are carried out automatically by the computer once the data has been entered. These programs have been touted as forecasters for financial people, permitting the asking of "what if" questions—i.e., they are general-purpose simulation languages. Inadvertently, their developers designed them so flexibly that they are useful as simulators in any discipline in which phenomena may be represented by sets of algebraic equations, even if those equations are nonlinear and time varying. Few have
noticed, but a spreadsheet program can simulate phenomena in biology, chemistry, engineering, physics or physiology just as easily as those in the financial world for which they were intended.

Data base programs fall into two classes: those developed commercially, permitting the user to search for information and organize the selected subsets of information into useful forms; and those which are generic and permit the user to create personal data bases for a variety of purposes.

**Epilogue**

When we realize that none of the educational applications which I have described above existed in a meaningful way three short years ago, and when we reflect on the potential impact which these applications will have on education, we must stand in awe of the future. Who can project what the next three years may bring? Imagine what educational computing will be like in a decade hence—if you can!

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**Retrospective Comments 8/4/05**

This Guest Editorial by Lud Braun mentions the Huntington Computer Project. This was a National Science Foundation funded project in the late 1960s and early 1970s. In my opinion, the educational software it produced was by far the best educational software available at the time, and for a number of years after the project ended.

I first "discovered" this software in about 1971, and immediately began to make use of it in my teacher education courses. The software included a variety of computer simulations, along with detailed materials for the teacher.

I eventually got to meet Lud, and we have been friends ever since.