Computer Center

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The BSCS and Educational Computing in the Sciences

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The Biological Sciences Curriculum Study (BSCS) is a not-for-profit {501(c)(3)} educational research and development institution whose purpose is the advancement of scientific literacy and education in the life sciences. During the past 27 years, the BSCS has virtually revolutionized the teaching of biology by developing educational materials used by more than 50 percent of the school districts in the United States, and in more than 60 countries in adaptations in 25 languages. The BSCS has developed almost 700 pieces of educational materials, including textbooks, laboratory manuals, subject-specific modules, films, documentaries for public television, and more recently, materials for educational computing in the sciences.

The BSCS has undertaken study of the uses of microcomputers in science teaching; already several projects in educational computing in the sciences are either underway or in the planning stages. There are many barriers to achieving the potential benefits of educational computing. Those barriers are found within the system of educational computing detailed by Crovello (1983)—people, software and hardware.

People

Problems

Teachers, administrators and trainers pose barriers to educational computing in the sciences. Science teachers as a whole are interested in learning more about educational computing; however, fewer than 20 percent indicate they have had training in this area. The teacher is the key to implementing any approach to instruction; therefore, until the majority of teachers are well prepared in the required knowledge and skills, untrained teachers constitute a major barrier to educational computing. Leadership is needed also to ensure the success of educational computing. School principals are acknowledged leaders of educational change; they must be better informed about their role in promoting educational computing and accept their responsibility to encourage its implementation.

However, for educational computing to increase in the schools, a new type of leadership is needed. A cadre of well qualified trainers is essential to provide the leadership for successful implementation of educational computing.

Solutions

A large-scale program for training the key people in the system of educational computing is needed to overcome the barriers described above. This will require several approaches tailored to the needs of the different groups of people. Workshops—concentrated short courses from two hours to two days in duration—are an effective method to present specific knowledge and skills. Workshops can be used to help teachers who have no experience with educational computing become novice users. The BSCS offers several workshops each year to science teachers on educational computing in the sciences.

Other training models include courses and institutes. Both afford teachers more time than do workshops to study designated topic areas. The credit course is the most common, existing method of training immediately available to both preservice and inservice teachers; this system is already in place. Therefore, an effective strategy for training preservice teachers and some inservice teachers is to add a unit on educational computing to existing courses for training science teachers. However, many inservice teachers need additional motivation to enroll in courses at institutions that train teachers. Therefore, the institute model is needed as a temporary means to meet the needs of interested inservice teachers. Institutes offer opportunities for greater coverage of the knowledge and skills; therefore, they are superior to workshops but are limited by restrictions of time and money. Also, institutes are effective means to change teachers and administrators into knowledgeable leaders.

One should not overlook self-study as a means to overcome the lack of trained teachers and administrators. Teaching is a profession and teachers and administrators have an obligation to keep current with new approaches and theories. Most of the present experts in educational computing have been self-taught. The greatest problem with self-study, however, is gaining access to materials that provide the necessary knowledge and skills.

We need materials on educational computing to train teachers and administrators. There is a need not only for dissemination of information to practicing teachers, but also for a curriculum on educational computing in the sciences to assist instructors offering preservice and inservice training. Even among courses offered at institutions of teacher training, there is little consistency in objectives and instructors may be ill-prepared because the subject is so new.

To provide trainers and training programs for science teachers, the BSCS and The Colorado College, with support from the National Science Foundation, are developing a curriculum for training science teachers (all grade levels and all science disciplines) to use the computer for educa-

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tional purposes. This project, titled ENLIST Micros, is developing a text, videotapes, slide-tapes and software to be used by trainers in a variety of settings (workshops, institutes and courses) with either preservice or inservice teachers. Those materials are being field tested during the fall of 1985 and will be evaluated and revised during the spring and summer of 1986. The revised materials will be distributed by a commercial publisher. We expect that those materials will help alleviate the shortage of opportunities for training in educational computing.

Another approach to the problem of training people involved in educational computing in the sciences is to disseminate information to help those people increase and improve their use of computers on their own. Information dissemination is important to all potential and experienced users as a means to keep current and is an important adjunct to the other training approaches that require personal contact with an instructor.

The BSCS staff has a primary responsibility to disseminate information on all research and development projects conducted by the BSCS, and often publishes position statements resulting from the study of important educational issues. Articles and reports by BSCS staff on educational computing in the sciences have been published in various journals, monographs, books and newsletters. In addition, the BSCS newsletter, published semi-annually, is used to publicize new projects and activities. The newsletter is available upon request from the BSCS.

Software

Problems

There are two general problems with software; first, for many applications, there is too little software of good quality; second, there is inadequate use of important applications. You can find a great deal of software for certain applications such as drill-and-practice programs for math or simulations programs of genetic crosses for biology. However, a review of available programs soon reveals that when considering a matrix of topic areas in science and types of software (drill and practice, simulation, tutorial, microcomputer-based laboratory, games) most of the cells of the matrix would be empty or have few entries. There is a conspicuous abundance of drill-and-practice programs and a dearth of other approaches. More recently, however, simulation programs are becoming more numerous. The problem is not that any particular type of software is inherently bad; it is that drill-and-practice programs offer the lowest level of cognitive learning. Although there may be a place for recall of factual information in science education, the emphasis should be on higher-level skills such as problem solving.

The other major problem with software is inadequate use. The most important use of the computer is as a tool to assist in organizing and manipulating information; however, many science teachers are not aware of how the computer can assist in the management of instruction. The use of word processors to create letters, lesson plans, laboratory activities and reports is an invaluable timesaver.

Database programs can be used to organize grades, inventories of equipment, collections of specimens (botanical, zoological, geological), and instructional activities according to prespecified traits and then to print the results as a report. Large databases can be accessed via a microcomputer to research a variety of subjects including educational computing, biology and educational research.

Solutions

The solutions seem obvious: develop more quality software in all areas of science and encourage science teachers to use the computer as a tool to manage instruction. The lack of quality software is a difficult problem to overcome. Ideally, the free-market system would drive the development of all of the needed software. However, the cost of development is so great and the risk of inadequate return so great that few publishers are willing to undertake more than the simplest applications such as drill and practice.

Methods are available to alleviate the software problem. In some respects, the problem with software does not lie entirely with the quality or quantity of software, it lies with the lack of congruence between the software and the objectives of extant curricula. Even where software exists, there is difficulty locating the software available for a given set of objectives. The solution to that problem is to establish a national clearinghouse for biology software that identifies, classifies and reviews all software pertaining to biology education. The clearinghouse could review curricula and key software to the objectives of those curricula. That would help teachers select software and would also make apparent to software developers where there are or are not needs for additional software. Here is an opportunity for an agency like the BSCS to play an important role in encouraging the use of microcomputers in science teaching.

Another solution to the lack of compatibility between software and curricula is to begin projects that coordinate the development of software with the objectives of extant and new curricula; this approach is already underway. Several textbook publishers are developing or planning to develop "textware"—software that is developed to support activities from a specific textbook. Curriculum development projects now planned by the BSCS include development of software as an integral component of the curriculum. More innovative plans by some educators include the development of curricula that have educational computing as the focal point of instruction. Whatever the approach, we must give greater attention to using the limited resources available to develop educational computing materials as effectively as possible.

Science teachers can help by collectively demanding specific types of software for particular topic areas. If a publisher can reduce the risk by knowing the demand is high, then many would be willing to develop that specific software. Until the market can successfully drive the development of software, additional support from public and private foundations will be needed to develop software in thin market areas and where the demand has not yet been established. Let's encourage foundations to support innovation that is not feasible for commercial agencies to undertake.

It is likely that the second problem with software, that is, barriers to using the computer as a tool to manage instruction, will gradually be overcome. Most teachers who acquire computers eventually learn to use word processors or databases without formal instruction. However, the time it takes to master such uses is great, and methods to facilitate learning are needed. Including word processing as a course in the professional training sequence of teachers may not be the best approach because word processing may be too basic of a skill to warrant college credit (just as typing is a skill learned outside of professional training). Developing independent-study guides for different applications of the computer in managing instruction might be a better approach.

Hardware

Problems

There are two major problems with hardware: the inadequate numbers of computers available to realize the potential of educational computing in the sciences and the lack of compatibility between different brands of computers. The problem of numbers seems to be solving itself as the number of computers in schools grows exponentially. As computers continue to decline rapidly in cost, more will be available in schools.

The problem with compatibility is a greater concern than quantity. At present, the vast majority of educational software in science will operate only on the Apple II systems. Apple II systems are also the most common computers in the schools. Teachers using systems other than the Apple II find a much greater shortage of educational software appropriate to science. The fact that most software packages have not been adapted for more than one system further limits the quantity of software available to any one teacher.

The problem of hardware compatibility extends beyond software and includes the problem of connecting peripheral devices (printers, modems, laboratory instruments) to a computer system. At present, it is difficult to use a printer to print graphics because different printers have different styles of printing graphics.

Solutions

The problems with hardware will be even harder to solve than those with software. The educational market for hardware is relatively small compared to the home market; therefore, the development of hardware is geared to the home market. Since the problems of hardware compatibility are not as great for owners in the home market, it is unlikely that changes will occur rapidly. However, it seems reasonable to expect that systems will become more compatible within the next decade. State and federal support is being used to obtain microcomputers for schools. Agencies like the BSCS can encourage schools to give careful consideration to the availability of software before selecting a particular brand of computer.

Where Do We Go From Here?

Educational computing, even with its rapid state of growth and change, offers many opportunities to science teachers to improve their planning and delivering of instruction. Caution is warranted for the large purchase of hardware and software because most will become outdated in a few years. However, an application that is cost-effective now will remain so in the future. Therefore, the BSCS recommends that science teachers acquire at least one computer system and that they use it first to help manage instruction, second to help students learn (data analysis, data acquisition and data processing), and third to provide instruction that can be provided more effectively by the computer than by traditional methods (remediation for basic skill and knowledge and simulation of models that can't be accomplished otherwise).

Reference

Crovello, T.J. (1983). Educational computing systems: The Compeace guide to evaluation of their hardware, software, and people. Compeace, Box 554, Notre Dame, IN 46556.

Research Reviews

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Jim Stewart edits this *ABT* department. He is an associate professor in the Science Education area of the **School of Education, Department of Curriculum and Instruction at the University of Wisconsin-Madison, Madison, WI 53706.** Stewart is involved in research on learning and problem solving in genetics. He is also researching the use of microcomputers in biology, particularly in relation to genetics, at the high school and university levels.

It has been some time since we have actually looked at science education research in which biology is the content. This month's articles, then, will all have a biology focus.

The first article appeared in the October issue of *Science Education*. The paper, "Students' Alternative Conceptions of the Human Circulatory System: A Cross Age Study," won for its authors, Mary Arnaudin and Joel Mintzes, one of four Awards of Merit for papers submitted to *Science Education*. The awards are: "To celebrate . . . important contributions to the future of science education. . . ."

Arnaudin, M. & Mintzes, J. (1985). Students' alternative conceptions of the human circulatory system: A cross age study. ***Science Education, 69*(5), 721–733.** The first author's address is Department of Biological Sciences, University of North Carolina at Wilmington, Wilmington, North Carolina.

The authors set out to construct a "conceptual inventory" of student conceptions of selected aspects of the circulatory system: structure and function of blood; structure and function of the heart; the circulatory pattern; circulatory respiratory relationships; and closed circulation. The students they studied were 5th and 8th graders, high school sophomores, college freshman nonbiology majors and college freshmen who were biology majors. The authors used a combination of concept mapping exercises, interviews and multiple choice tests to gather data.

Before describing specific results, it is worth noting one of the general claims that they make: "In a number of instances, the relative frequencies of alternative conceptions common to elementary school students remained stable at the secondary and college levels." The authors argue that this conclusion fits squarely within the claim of other alternative conceptions of researchers, that student alternate conceptions tend to be very resistant to change.

Specifically, it was found that:

1. Although the dominant view of 5th graders that blood is a red liquid diminished by 8th grade, it was nonetheless held by about 20 percent of the 8th and 10th grade students. Two alternate views, each of which were held by 10 percent of 5th graders (blood is cells suspended in red liquid or red cells without intercellular fluid), actually increased in older students. About 30 percent of college freshman biology majors held each of these views.
2. The function of blood for elementary school students was very general (it keeps us alive); the percentage holding this view dropped among older students but might still be considered