SIMULATION AND COMPUTER-BASED TECHNOLOGIES FOR EDUCATION

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ABSTRACT

The paper presents results from a study of how effectively technology has been implemented in K-12 classrooms. The study also examined the need to train current and future teachers on the use of educational technologies, through inservice and preservice training programs and within colleges of education. The paper will discuss how and why the Department of Defense (DoD) can assist in this implementation.

The objectives of the study included (1) to recommend uses of DoD simulation and other computer related technologies for school systems and (2) to recommend how to effectively integrate technologies into these school systems. Literature searches, site visits, interviews, the use of consultants and presentations given at a forum produced several findings and recommendations that are reported in the paper.

ABOUT THE AUTHORS

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The U. S. Department of Defense (DoD) has historically been involved in the preparation for and conduct of wars. With so many world-wide responsibilities, why should any branch of the military be getting involved in the field of public education? Then, assuming there is a logical reason to get involved, how can they be most effective in doing so? These were questions that were presented to staff members at the University of Central Florida Institute for Simulation and Training (UCF-IST) last year. The resulting nine-month study, Simulation and Computer-based Technology for Education, was sponsored by the U.S. Air Force through the Wright-Patterson Air Force Base in Dayton, Ohio (Medin, 1995).

BACKGROUND

Our study found that the DoD and its military branches have traditionally played a decided role in assisting educational endeavors, including offering assistance to K-12 and post-secondary schools and supporting teacher training. The DoD actively demonstrates this role in selected U.S. locations and internationally in Department of Defense Dependents Schools Systems (DoDDS) which are available for use by military personnel and their family members. Each military branch also employs a large number of scientists and engineers to develop training programs.

The question, therefore, was not whether or not the DoD and its military branches should become involved in assisting public education endeavors, but in which manner should they proceed in order to assure the most effective results? In pursuit of the answer to this question, a study was conducted based on three objectives:

- review existing military simulations and other computer-based technologies for the purpose of recommending those most suitable for transfer and subsequent use in public and private schools;
- develop recommendations for the effective integration of technologies into these school systems`; and
- chart the results of this study in order to provide recommended solutions for U. S. Air Force training needs.

METHOD

The following five methods for collecting data were conducted:

- a review of available research literature;
- reviews of information available on the Internet and the World Wide Web;
- interviews with key stakeholders and military, government, and civilian officials in various schools, agencies, and laboratories;
- on-site visits to schools and military bases; and
- forum presentations.

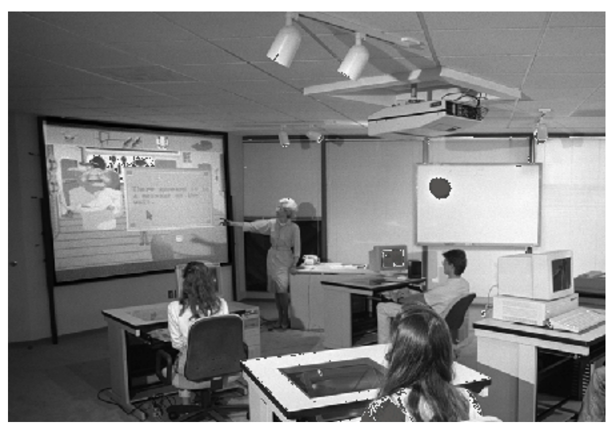

Figure 1. Educational technology in use in a classroom.

Site Visits

On-site visits were conducted by team members of UCF-IST to observe a sampling of successful teaching strategies using computer-based technologies (see Figure 1). Visits included the observation of innovative programs within industry, university and military sites, in addition to site visits to public and private schools.

FINDINGS

Teachers and trainers may use technology for a variety of reasons, but ultimately getting and keeping students engaged in learning is the strongest motivation. Teachers who use technology in the classroom often report that its use can make learning more relevant to real world experiences, and therefore more motivating to students (OTA, 1995). Educational technology involves a combination of human and nonhuman resources to bring about more effective instruction (Knirk & Gustafson, 1986). Educational technologies include computers, videodiscs, models and simulations, multimedia such as CD-ROMs, and telecommunications networks (OTA, 1995).

An increase in communications between teachers and administrators, colleagues, parents of students, and experts in the field is one of the most significant improvements technology offers classroom teachers. Telecommunications, from basic telephones to advanced networks, will transcend the walls of isolation that tend to prevent teachers from keeping in touch and up-to-date. In fact, teachers who are leaders in the integration of telecommunications and other technologies are demonstrating how technology can be a vehicle for continuing professional development, and are reporting a renewed sense of professionalism when they take part in such activities.

The use of educational technologies has demonstrated a significant positive effect on student achievement, on student attitudes toward learning and on the self-concept of students (Sivin-Kachala & Bialo, 1994). Positive effects have been found for all major subject areas, on all grade levels, for general education as well as for special needs students (Sivin-Kachala & Bialo, 1994). When utilizing computer-based instruction, students believed they were more successful in school and were more motivated to learn (Sivin-Kachala & Bialo, 1994). However, positive changes in the learning environment brought about by technology are more evolutionary than revolutionary as the change agents (i.e., teachers and administrators) become more experienced with technology and have a vision of how it can be deployed (Sivin-Kachala & Bialo, 1994).

The higher the grade levels present at a school and the larger the student population, the more likely the school will own any given technology (SPA, 1994). It must be noted that the presence of technology resources in a school should not be taken as an indication that the teachers are using them. There is a gap between access and use.

Student-related Outcomes

When instructional content and strategies meet accepted educational standards, research(SPA,1994) has shown that technology

- increases performance when interactivity is prominent;
- is more effective with the use of multiple technologies (e.g., video, computer, telecommunications, etc.);
- improves attitudes and confidence, especially for high risk students;
  improves student collaboration on projects;
- increases mastery of vocation and work force skills; and improves reading and writing skills (see e.g., (Sivin-Kachala & Bialo, 1994).

Teacher-related Outcomes

Research (SPA,1994)supports the conclusions that the use of technology by educators generally results in

- increased emphasis on learner-centered strategies and decreased emphasis on lesson-centered instruction;
- increased emphasis on individualized instruction;
- increased interest in teaching on the part of teachers;
- an increase in administrator and teacher productivity;
- an increase in lesson planning and collaboration with colleagues; and rethinking and revision of curriculum and instructional strategies (See e.g., Sivin-Kachala & Bialo, 1994,

Lazarus & Lipper, 1994; and OTA, 1995).

A growing body of research supports the notion, however, that the effectiveness of educational technology depends on a match between the goals of instruction, the characteristics of the learners, the design of the software, and the technology implementation decisions made by teachers (Sivin-Kachala & Bialo, 1994). As long as the focus for technology integration remains on the equipment and software rather than on systemic change, schools across the nation will continue with the present practice of placing the bulk of technology use in practice and remediation of basic skills.

Survey data reveal that drill and practice applications are the most commonly used of computer-based technologies in elementary schools (Becker, 1993). In high schools, integration of technology is minimal as computer-related subject areas are usually covered in a separate course where the emphasis is on learning to use utility software outside the context of any curricular area (Becker, 1994). Only a small percentage of students are enrolled in these elective courses at the high school and middle school levels, thus effecting the validity of data that is based on average time-on-task per student. While a small number of students seem to be spending a large amount of time at the computer, a large portion of students still spend little or no time at all using computers. Indeed, in some purportedly high-tech schools, a number of students may graduate without ever using a computer.

Proponents of student computer use tend to assume that, given adequate or even copious technology resources, teachers can and will use the technology in some learner-centered fashion. A study of teachers' behaviors in computer-rich environments however, belies this assumption and reveals that teachers who spend a majority of their time providing information in the lecture-centered classroom will tend to use the same teaching strategies in the computer laboratory as well (Carey & Sale, 1993).

Military Programs for Education and Training

The military branches invest tremendous amounts of time and resources to train personnel. When not at war, their mission is to maintain overall readiness through training. For this reason, they continually attempt to improve training methods by studying, and often implementing, new and innovative training systems. In the late 1970s, the DoD adopted a systems approach to training management (Cosby, 1995; TRADOC, 1988). That is, the learning environment has since been viewed as a series of inputs, throughputs, and outputs which when used in combination produce specific learning outcomes (e.g., the acquisition of knowledge, skills, and abilities related to the performance of one or more tasks). One of the benefits of the systems approach to instructional design has been that it lends itself to the development of computer software intended for use by novice instructional designers in their development of effective instructional courseware and materials. A systems approach has also contributed to the development of corresponding instructional management materials that instructors can use to facilitate the learning process (e.g., train-the-trainer materials).

Figure 2. Military reservists in a distance learning classroom.

Instructional technologies that are currently in use by the military include computer-based training (CBT), computer assisted instruction (CAI), intelligent tutoring systems (ITS), simulation, and distance learning (see Figure 2). Training systems that incorporate simulation technology have proven to be highly effective, and in many cases have the added benefit of reducing overall training costs (see e.g., Hays, Jacobs, Prince, & Salas, 1992; Orlanski & String, 1981). They are currently developing a highly complex and technologically advanced training capability called distributed interactive simulation (DIS) in which various simulations, simulators and instrumented equipment are interconnected in a shared 'virtual' environment that allows for the conduct of real-time, interactive exercises.

Due to the extensive use of training and ongoing research involving innovative training methods, our study found that the military branches have much to offer in terms of transferring training technology experience, skills, and lessons learned to a K-12 environment. Several CBT instructional design tools, along with general principles gleaned from train-the-trainer instructional materials, may be of particular benefit to schools, because they offer readily available training or training development tools that can facilitate educational outcomes. In addition, simulation and computer-based technology applications have proven benefits that hold promise for providing an expanded learning environment to classrooms and members of the community.

DISCUSSION AND IMPLICATIONS

Overcoming the Barriers to Transfer

The use of simulation as a learning environment in which students can test hypotheses and track their decisions is a potentially effective application that is largely neglected in K-12 and post-secondary schools. There are several possible explanations for the lack of integration of simulation technology, including perceived barriers, barriers of tradition, complications in technology insertion, lack of effective planning, and lack of sufficient teacher training. In addition, simulations are considered to take up large amounts of curricular time. However, computer software such as simulations can be integrated into a variety of instructional objectives, once they are no longer considered a source of 'busy work' for students who have completed their assignments.

Perceived Barrier. Commercial vendors of educational technologies, among others, have convinced teachers that only state-of-the-art equipment will meet their students' needs. Yet, most state-of-the-art equipment that is found in schools is not available in sufficient numbers to make a difference in student learning. After the one or two years that it takes to train teachers to use the equipment creatively, the equipment is yesterday's news and the search begins anew for more modern equipment. Funding by granting agencies fuels the attention given to the latest available technologies, while teachers and administrators continue to grapple with the basics such as word processing. Perhaps providing a new technology should not be viewed as more valuable than first providing instruction which leads to comfort in using what is already available.

Barrier of Tradition. The change from a teacher-centered, information-providing learning strategy to one that is student-centered and facilitation-providing is a difficult one for teachers. Traditionally, teachers have taken on the role of information giver, and have maintained ultimate control of the classroom environment. The most recent trend for innovative instructors is based on obtaining access to information provided by the Internet. Via the Internet, teachers and students may gain access to copious amounts of up-to-date information by downloading it from worldwide networks. Such innovations have sparked the imagination of many educators, and may serve to break down the barriers of traditional instruction.

Complications in Technology Insertion. In schools across the U.S. that now utilize computer technologies, more and more have technology insertion plans rather than programs that integrate appropriate technologies into a revised technology curriculum. Asking teachers what they need merely results in the insertion of educational technologies into an existing system that already lacks effectiveness. As Seymour Papert (1980) stated, "There is a need to change the system to incorporate the changes that technology will allow. Otherwise, if it's treated separately, it's like attaching a jet engine to an 18th Century horse-drawn cart and assuming it can make a horse go faster."

Lack of Effective Planning. School systems are not consistently planning ahead. About 60% of school buildings in the U.S. today are over 50 years old (Van Horn, 1995). Most plans for new or retrofitted schools are too short-sighted in their accommodation of future curricular developments and innovations in educational technologies.

Insufficient Teacher Training. Providing training for teachers on the use of technology, along with technological support for these teachers, is at best experimental. Despite the availability of educational technologies in many schools, a substantial number of teachers report they do not use computers and other technologies regularly for instructional purposes (OTA, 1995). To ensure the effective use of educational technologies, teachers need to have opportunities to visualize potential uses, experiment, and then apply the technologies in the classroom setting. In addition, teachers need training and just-in-time technical support (OTA, 1995). It is not realistic to expect teachers to provide their own resources on their own time for learning to use educational technologies.

Marketing Issues

It is important from a marketing perspective that both public and military sectors engaged in the transformation of military-developed technologies conduct a thorough analysis of the current market situation. Before developing software for public education, military institutions seeking to transfer technology should ask, "What do we have that the public can use?" and, "What are the needs of public schools that the military might be able to satisfy?"

Figure 3. Student with helmet-mounted virtual reality display.

Most schools will readily accept free software or free computers along with funded technology support. Acceptance of these, however, does not assure that they will be used effectively, if at all. We suggest that the military branches determine their areas of competitive advantage over private vendors. In particular, the military branches have the budget to research and develop sophisticated applications of technology in such areas as expert systems, artificial intelligence, and virtual reality (see Figure 3). Companies marketing computer-based products to the K-12 and post-secondary school markets cannot justify the development costs of these applications due to limitations in return on investment.

Recommendations

Suggested Roles for the DoD and the Military Branches. On the basis of our research, we recommend that the military branches increase their involvement in K-12 education. The military branches have the critical challenge to remain trained and ready, while growing more capable. Each year, they are faced with the tremendous task of choosing new recruits from among those who are ready and willing to serve, and deciding in which specialty each person should be trained. Our study suggests that the objectives for establishing enlistment standards and matching recruits to jobs should be reviewed for adequacy in relation to the current status of K-12 education.

It is also our opinion that identification of technology-related skills and mastery of basic education competencies that could be taught prior to enlistment through a K-12 curriculum would alleviate some resource requirements throughout the military. We suggest that analyses of training programs are needed to match the specific skills and competencies required for occupations in the military. Involvement and encouragement on the part of the DoD and its military branches in the development of appropriate curricula for K-12 schools, the development of alternative training approaches, and the identification of occupational skills are all critical to meeting the need for cost reductions in the military without creating a reduction in the future force's capabilities.

We have seen that the DoD and its military branches have a proven research and development success record. It is our opinion that they should utilize this excellence to assist K-12 schools, community colleges, vocational schools and universities in determining how best to apply educational technologies.

We believe that the DoD and its military branches have demonstrated that the combined efforts of government, industry and academe can make remarkable breakthroughs in the development of sophisticated prototype systems. They can assist in bringing together key groups who can implement technology utilization in schools, and aid in the training of teachers and administrators.

We have also seen that the DoD and its military branches have developed many training courses for a wide range of military uses. Industry has also developed training courses for its purposes. With additional funding and guidance, public schools will develop prototypes that will be of benefit in much the same way. For instance, we suggest that

- public school curricula will be enhanced by the integration of technology through the use of artificial intelligence and other technologies in course modules;
- networks will be developed through which teachers and other staff members can utilize the Internet and other educational databases;
- public school systems, community colleges and universities will develop simulation-enhanced courses;
- the DoD and its military branches might assist in establishing state-of-the-art training facilities for teachers, administrators and other pertinent staff members of public schools; and
- military laboratories, such as Armstrong Lab in San Antonio, Texas, might invite teachers to be trained in the utilization of educational technologies.

Suggested Role of the Educational Environment. Before implementing technology in a public school system, we suggest that a well-designed plan should be developed. An effective five-year technology plan should include an analysis of the learner population and their families and communities; the participation of change agents and administrators that possess a knowledge of the use of computers in education; extensive input from the educators whose lesson plans will be impacted; and provisions for teacher training and technical support.

We also suggest that a formal education program for administrators and supervisors is essential to the change process. Understanding the application of educational technologies and incorporating the various capabilities into the schools will require the leadership of change agents to break through old paradigms. An effective technology plan will take into account several factors, not the least of which is the number of years that the school will be in use. Incorporating insightful facilities planning will help avoid costly renovations as new educational technologies are developed.

Our study found that providing technology training and ongoing technical support for educators is slowly being recognized as a vital part of the integration process. At this time, technology training is either short in duration or non-existent, requiring teachers to learn on their own or from their students. Many computers and computer-based technologies sit idle in K-12 schools across the nation; an unfortunate situation which could have been avoided if technology plans had been allotted funding for training and resource programs.

The most effective technology integration programs offer both initial and on-going training for teachers. They allow teachers to use and experiment with computers until they are comfortable before placing technologies in the classroom for the student use. Although many schools are experimenting with technology training, the military has a history of developing training programs. We suggest that this is another area of integration in which the military can assist.

Educational technologies must fill a need. Revised standards within the curricula are needed so that students may progress from learning basic computer skills to a required use of computers for mastery of curricular tasks. It is important to remember that, in addition to strong basic skills like reading, writing, calculating and critical thinking, new information skills are essential to helping students adapt to the changing technologies they will meet in the workplace (Lazarus & Lipper, 1994). Forty-seven million K-12 age children in the U.S. are enrolled in public schools, and could acquire information literacy if it were effectively integrated into the school curriculum (Lazarus & Lipper, 1994).

We suggest that colleges of education incorporate the use of educational technologies into their training of future teachers. Most new teachers today graduate from teacher preparation programs with limited knowledge of the ways technology can be used in their professional practice, from administrative aids to instructional tools (OTA, 1995).

Our study also concluded that there is good reason for the military branches to continue their involvement in education. They have established that simulation can be a less costly method for training military personnel, in terms of savings in human lives and financial costs. Some military recruits are entering the armed forces without technological training at a time when the military branches are relying heavily on the use of technology. Also, defense-related industries have an increasing need for technologically skilled personnel. If this knowledge is not mastered in the K-12 school experience, then the expense of training will fall to the DoD and the military branches, or will be reflected as overhead costs that are passed on to the DoD and military branches by industries, either directly or indirectly.

We therefore believe that it is cost effective for the DoD and the military branches to provide the expertise that K-12 schools are currently lacking. Formal employee training and education costs U.S. industry about $50 billion per year, with still another $30 billion imbedded in on-the-job learning (Fitzsimmons, 1995). We suggest that as the DoD, its military branches, and defense-related industries progress toward increased computer automation, the cost benefits of providing opportunities for students in K-12 schools to learn computer skills before they are eligible for recruitment will become more evident.

The views expressed in this article are those of the authors, and do not reflect to official policy, or position of the U.S. Air Force, Department of Defense, or the U.S. Government.

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