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AUTHOR	Wright, Vivian H.; Marsh, George E.; Miller, Michael T.	
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ABSTRACT

This paper summarizes the historical growth of technology and the research that has examined this evolution. Important stages of instructional technology are explored, including the development of computer-assisted instruction and the growing use of the Internet in learning. With this medium's growth will come new opportunities for research and use in educational settings through Web-based instruction for distance learning. Although technology development continues to move at a rapid rate, scholars will have consistent challenges in assessing issues related to productivity, effectiveness, performance outcomes, and assessment. Technology administrators must consistently match technological advances with evolving institutional, student, and faculty needs. (Contains 48 references.) (Author/AEF)

An Historical Analysis of Instructional Technology in Education

Vivian H. Wright, Ph.D.*

Assistant Professor
Area of Teacher Education
College of Education
Box 870232
The University of Alabama
Tuscaloosa, AL 35487
(205) 348-1401
Email: vwright@bamaed.ua.edu

George E. Marsh, Ed.D.

Professor
Instructional Technology Program
University of Alabama

Michael T. Miller, Ed.D.

Associate Dean
College of Education
San Jose State University

*Corresponding Author.

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Abstract

This article summarizes the historical growth of technology and the research that has examined that evolution. Important stages of instructional technology are explored, including the development of computer-assisted instruction and the growing use of the Internet in learning. With this medium's growth will come new opportunities for research and use in educational settings through web-based instruction for distance learning. Although technology development continues to move at a rapid rate, scholars will have consistent challenges in assessing issues related to productivity, effectiveness, performance outcomes, and assessment. Technology administrators must consistently match technological advances with evolving institutional, student, and faculty needs.

An Historical Analysis of Instructional Technology in Education

The most significant breakthrough in modern computing has been the miniaturization of electronic components, which has made it possible for the continual reduction of computing costs (Heinich, Molenda, Russell, & Smaldino, 1996). The first major development was the transistor, which replaced the vacuum tube. The following development was the invention of the integrated circuit stored on a silicon chip. The chip made computers smaller, increased their power, and reduced the amount of electricity required for operation. By packing chips with many circuits, desktop computers were possible. Experiments continue with the promise of making computers even more powerful and inexpensive.

The prevalence of fast, relatively inexpensive computer technology and software has made it possible for schools to use computers in ways that were inconceivable just a few decades ago (Heinich et al., 1996). Five important stages in the use of computers for instructional purposes spanning four decades may be identified: (a) the work of Suppes, (b) the PLATO system, (c) the TICCIT system, (d) development of the microcomputer, and (e) the Internet.

Patrick Suppes developed the first computer-assisted instruction (CAI) at Stanford University in the 1960s. Suppes designed highly structured computer systems, probably influenced by the popularity of Skinnerian instructional techniques, so that his software used feedback, lesson branching, and student record keeping (Suppes, Jerman, & Brian, 1968). While Suppes experiments were interesting, particularly because he defined and set the initial standards for computer-assisted instruction (CAI), the use of CAI was never widespread in universities or schools during the 1960s, probably due to expense involved in gaining access to computer terminals.

During the 1970s, the National Science Foundation supported TICCIT (Time-Shared Interactive Computer Controlled Information Television) and PLATO (Programmed Logic for Automatic Teaching Operation) to examine computer-aided instruction (CAI) in comparison with traditional classroom instruction (Saettler, 1990). TICCIT was conceived as a primary means of instruction for college students using a combination of television, graphics, and content delivered via computer. While the results of instruction were considered to be significantly better than traditional instruction (Chambers & Sprecher, 1983), students preferred lecture classes to TICCIT. Chambers and Sprecher explained that many students were affected by the attitudes of their college instructors who may have felt threatened by the technology. Also, TICCIT provided inadequate feedback for students.

Using a more traditional approach, the PLATO system was a collection of hundreds of tutorial and drill-and-practice programs. Similar to the TICCIT system, students could access PLATO through timesharing on a mainframe computer (Coburn, Kelmer, Roberts, Snyder, Watt, & Weiner, 1985). These researchers noted that these programs showed that while achievement could be equal to or superior to traditional instruction, there were a number of social factors that entered into the interaction. As with TICCIT, students were isolated from other students and interacted on slow computer terminals.

Technically, CAI, PLATO, and TICCIT demonstrated the effectiveness of computer-based instruction, despite social and technical problems and high costs. The mass produced microcomputer became the next alternative in the early 1980s. The availability of computers in homes and schools created a demand and a market for educational software that has been met by new companies, many of them learning lessons from the successes and mistakes of the TICCIT and PLATO experiments (Heinich et al., 1996). In 1986, there were already more than 7000 commercially produced educational software programs (Jolicoeur & Berger, 1986), and today the number is so great it is impossible to estimate how many programs are available. With the increased availability and uses, research in assessing the value and learning outcomes of educational software also increased.

Instructional Technology Research

This next section explores what CAI, CAL, and CBT are to the instructional technology field. The emerging use of the Internet is also discussed. Available research is summarized for these instructional technology methods.

Computer-Assisted Instruction (CAI)

CAI was descended from "programmed instruction" used by B.F. Skinner (1953). In programmed instruction the content to be learned is broken down into small pieces for learning. There are two methods, linear and branching. In the linear methods, the student is given a problem and provided with immediate corrective feedback and must try again. In branching, the student may receive several alternative paths with different examples that ultimately return to the main path. The key is that the student is not permitted to advance until passing each step. CAI programs have received significant criticism from the beginning, including questions about quality and assertions that they are boring and are often referred to as "drill and practice." While CAI has been found to be highly effective (Niemiec, Blackwell, & Walberg, 1986), the requirement for the student to follow precisely the steps laid out by the programmer may be tedious to some learners and uninteresting to teachers.

Computer-Aided Learning (CAL)

CAL followed CAI as a form of repair for the limitations of CAI. CAL was conceived as an "aide" to assist the student in thinking and solving problems, not internalizing facts. The primary method of delivering CAL was by means of the videodisc and CD-ROM (Pett & Grabinger, 1995). With the advent of the Internet, usage of the videodisc and the CD-ROM are becoming technically obsolete.

Computer-Based Training (CBT)

CBT has been highly successful in corporations and the military. CBT is difficult to distinguish from CAL, except that it focuses on narrow concepts for training. The training is self-paced and private. Kulik, Chen-Lin and Kulik (1991) studied the educational value of computer-based instruction such as CBT and found substantial improvement in learning outcomes and speed. However, as Ehrmann (1995) noted, such uses are not prevalent in higher education.

Research on Instructional Technology Use

Important to note is that CAI, CAL, and CBT are considered forms of instructional technology use. Instructional technology has evolved from overhead and filmstrip use to worldwide communication techniques, such as Internet, electronic mail (E-mail) and videoconferencing. Computer use is now prevalent in instructional technology classrooms and a continuing issue is whether all this technological hyperbole is "worth it." Common questions asked by researchers include whether instructional technology methods increase student performance, effectiveness, and efficiency.

Schrock (1995) defined instructional development from a systems approach of planning, designing, implementing, and evaluating effective and efficient instruction. Programmed instruction was refined in the 1950s with Skinner's behavioral research (1953), and Bloom's Taxonomy of Educational Objectives (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). In the 1960s, Glaser's (1962) work in instructional systems and Gagne's (1962) analysis of learning objectives became instrumental in implementing evaluation and feedback into instructional development goals. With prevalent federal research and development, instructional development models grew from these activities throughout the 1970s. By the 1980s, analysis processes were included in planning and instructional development became more sophisticated, just in time for the emerging growth of microcomputers and the rapid use of instructional technologies in business.

A common problem in instructional technology research is that test results have varied. Kulik, Kulik, and Cohen (1980) examined over 300 studies relating to educational technologies' effectiveness, students' assessments, outcomes, and other areas. As a result of this meta-analysis, they found positive student achievement outcomes. While Kulik et al. noted that technology's effects are not large ones, they also reported that "negative results were the exception rather than the rule" (p. 204). In Russell's (1998) examination of 248 research reports from 1928 to 1996, comparing traditional instruction with various forms of alternative instruction, such as television, closed-circuit television, satellite, teleconferencing, videotape, and computer-assisted instruction, the innovations were found to be equally as effective as traditional instruction. Government and military studies have indicated success using computer-based technology. However, Plowman (1997) wrote that these studies could be tainted due to an organizational need for justification of funding.

Productivity through increased technology use in education needs additional research. Gilbert and Green (1997) noted that with technology moving at a fast pace, it is difficult to evaluate its productivity effectively. Aitken (1997) referred to this as a reflection of Moore's Law, in which he noted that former Intel Corporation CEO, Gordon Moore, stated that technology doubles its performance at any given price level every 12 to 18 months. This makes it difficult to conduct longitudinal studies of productivity (Plowman, 1997).

Norris and MacDonald (1993) cited various examples in military services, businesses, and in higher education where technology's tools have successfully saved time and money, increased performance, and reduced learning costs. They recommended innovative integration of technology into the administration of higher education through collaborative efforts from high school to college and business. Norris and MacDonald stressed the need for faculty members to become facilitators of knowledge and learning in efforts to increase the students' responsibility for learning.

Boettcher (1992) based successful use of technology on four criteria, arguing that investment in technologies should have a clear learning purpose, enrich the curriculum, be generalizable, and target areas of difficulty. Boettcher studied the University of Illinois at Urbana-Champaign's computer-based instruction program, which showed increased learning and reduced costs. The school's program has been emulated by many institutions (Norris & MacDonald, 1993). Even with this success, research has consistently shown that technologies to facilitate learning are more dependent upon specific learning contexts (Kozma, 1991; Najjar, 1996). Kozma noted that the media can complement processing capabilities of the learner. Many factors affect learning, including a student's background, motivation, and learning goals (Recker, 1997). Mintz (1996) implied that a teacher can increase interaction time between student and teacher and student-to-student by letting the computer provide the data presentation and evaluation. Mintz also noted that programmed instructional models can incorporate strategies for presentation, testing, and feedback.

Loyd and Gressard (1984) developed the Computer Attitude Scale (CAS) that represented items relating to anxiety or fear of computers, liking of computers or enjoying working with computers, and confidence in ability to use or learn about computers. The study presented coefficient alpha reliabilities of .86 for the Computer Anxiety statements, .91 for the Computer Liking statements, .91 for Computer Confidence statements, and a total score of .95. Loyd and Gressard recommended the CAS as a stable instrument to "document current computer attitudes and changes in computer attitudes as a result of a computer education program" (p. 505).

Clark and Kozma are two of the researchers who debated the issue of how media influence learning. Clark (1983) argued that studies that show achievement gains are often misinterpreted. Clark proposed that uncontrolled designs, variances in the instructional strategy and content, and the novelty effect for new media might more likely explain increased achievement and performance. He further pointed to Kulik et al.'s (1980) study that showed that when the same instructor delivers both the experimental and control treatments, the media's positive effects are lower. Clark (1983; 1985) stressed the importance of maintaining consistency with all treatments. He wrote, "It seems reasonable to assume, therefore, that media are delivery vehicles for instruction and do not directly influence learning" (1983, p. 453). Clark believed that research should focus on characteristics of instructional methods and not the medium in which they are delivered. In a study with computer based instruction (CBI), Kulik (1985) concluded that the CBI's teaching method accounted for the significant learning gains versus the computer delivery of the information. Clark (1994) noted that learning gains should be attributed to the "active ingredient" of instruction and not to the delivery medium. Clark (1994) concluded that "absolutely any necessary teaching method can be delivered to students by many media or a variety of mixtures of media attributes--with similar learning results" (p. 27).

Kozma (1991; 1994) challenged this and proposed that perhaps researchers have not made a relationship between media and learning. Kozma believed that the attributes of media types should be considered, unlike Clark (1983) who contended that attributes are not medium exclusive. In response, Kozma argued "But the fact that other factors contribute to learning does not preempt a role for media" (1994, p. 16).

Some researchers, however, have argued that any medium used, such as the Internet, should simply be viewed as another medium to deliver information and enhance learning. Kozma (1991) contended that medium and method have a more integral relationship; both are part of the design. Within a particular design, the medium enables and constrains the method; the method draws on and instantiates the capabilities of the medium.

Kozma further stressed the need for instructional designers of emerging technologies to strive to understand the relationship between the technologies' capabilities and those of learning. Tyckoson and Jacobson (1993) recommended that instructional methods consider learning styles while providing different options. Clark (1994) defined the differences in technologies as being of either instructional/training or delivery designs. Clark billed those technologies that strive to select information and then design the delivery to enhance achievement as instructional training. The other, delivery technologies, provides the information and makes it accessible.

While various studies showed the value of technology in teaching and others showed no significant difference, the Panel on Educational Technology for the President's Committee of Advisors on Science and Technology (1997) noted that researchers should continue to place emphasis on research. The panel promoted continued implementation of well-designed, systematic research.

Distance Education and the Internet

Studies of various instructional technology techniques, particularly those related to distance education, such as television and computer-mediated communications have consistently shown little difference between traditional and non-traditional methods. In a comparison study, Barry and Runyan (1995) noted that while student achievement in distance education is comparable to that in traditional methods, the economic benefits of this delivery to a larger population should not be ignored.

Despite comparison studies, researchers continue to examine distance education's potential effects. Ellsworth (1997) pointed out that many studies of technology in education show no significant difference from traditional methods. Additionally, Russell (1998) examined 248 research reports from 1928 to 1996, comparing traditional instruction with various forms of alternative instruction. In each case, the innovation was equally as effective as traditional instruction, prompting Russell to call this the "No Significant Difference Phenomenon." This may be interpreted that regardless of the actual quality of traditional instruction, distance education is just as effective. Asynchronous and non-traditional technological models, such as the Internet, can be feasible options for learning.

The business world is exploring ways to use the Internet to encourage collaboration and share ideas with other employees and colleagues at remote business sites. Ghilardi (1997) noted that much of what is presented on the Internet is "elaborate document management rather than actual knowledge management" (p. 99). Marshall (1997) referred to knowledge management as a method to "harness intellectual capital within an organization" (p. 93). Marshall further recognized that knowledge management theory is important to businesses because knowledge should be recognized as the greatest asset to a business, rather than simply considering it as information.

Businesses are beginning to recognize this through the building and use of intranets to share internal and external information. Such intranets can enable employees to create knowledge by sharing information, thereby facilitating knowledge through active participation (Ghilardi, 1997).

Lucier (1992) stressed the need for a knowledge management environment in which a multidisciplinary team consisting of faculty, staff, computer scientists, librarians, and others share responsibility for collecting, storing, presenting, and using information through effective uses of technology. "The technology is now available to bridge information and knowledge. It is up to information professionals to provide the link between theory and practice" (Marshall, 1997, p. 98). Gifford (1992) referred to Gapen's definition of knowledge management as

> [the] means by which librarians can help scholars and universities retain control of the intellectually-generated property that is their most precious and valuable commodity. It is a way of structuring new works as they are created, so that they are maximally accessible and a way of accessing existing resources to enable the highest level of integration with the scholar's work, helping to create new knowledge. (p. 17)

The Internet is already providing information and communication capabilities (Lowyck, Elen, Proost, & Buena, 1995). Information overload is a concern of both educators and students. With the information highway and the creation and proliferation of technology's tools, educators are in the position to "revolutionize the way humankind learns" (Plowman, 1997, p. 23). Transforming information into knowledge is an important challenge to educators and, as Gifford (1992) noted, "it is the process of meaning-construction" (p. 17). Gifford further noted that teachers' roles in higher education are changing, as is the information delivery format. Gifford stated that the "lecture format is quickly becoming obsolete" (p. 18) and that "students learn how to learn, that is, how to access information and do the meaning-construction work needed to transform information into knowledge" (p. 18).

Schutte (1998) found that students who participated in a virtual classroom perceived more learning flexibility. Schutte conducted an experimental design on 33 social statistics students; 17 were randomly assigned to a traditional class and 16 to an asynchronous, virtual format. The virtual class used technology, which included electronic mail and the World Wide Web. The traditional class met in a formal classroom with scheduled lectures. Posttest results indicated the virtual class scored higher on the standardized examinations and had a higher perceived peer contact than did the traditional class.

The view of the Internet as an environment that supports communication and collaboration enhances an active approach to learning (Hancock, 1997; Riel, 1994; Wilson & Marsh, 1995). This active approach to learning has the potential to greatly enhance learning outcomes and the impact that educational providers can have on the learning community.

Discussion

Acceptance of technology can be simple and complex. Technology allows educators many options for communicating, facilitating, and enhancing learning. An increasing number of institutions are looking to the Internet in delivering information. With this medium's growth will come new opportunities for research and use in educational settings through web-based instruction for distance learning. Although technology development continues to move at a rapid rate, scholars will have consistent challenges in assessing issues related to productivity, effectiveness, performance outcomes, and assessment. As with previous technologies (i.e. television and video), a community of users, including educators, is quickly accepting the Internet, although uses vary.

The challenge seems to be how this technology may be used as a tool to facilitate knowledge management and knowledge sharing. Gifford (1992) noted that teachers' roles in higher education are changing, as is the information delivery format. Gilbert and Green (1997) stated, "Long term deep educational change must be driven by educational visions, not technological visions" (p. 38). These visions may vary as educators search for efficient ways to meet the expectations of a changing student population. Web-based instruction may make learning more accessible and flexible, while reducing per unit costs of education (Owston, 1997). Using the Internet as an informational delivery vehicle may alleviate some institutions' problems with scarce resources and may address needs of a changing and diverse student population, which may prefer alternative instruction.

When the focus turns to improved student learning, research varies on how different forms of media influence learning. Consistency in the delivery, particularly with the same instructor, seems to lower media's positive effects on learning (Kulik et al., 1980). Clark (1983, 1985) maintained that a teaching method can be delivered through many different forms of media with the same results. Kozma (1991, 1994) believed that media's attributes are important and can contribute significantly to the learning process.

The underlying theme in the literature base and in the growing practical arena is that technology should enhance instruction rather than replace traditional instruction. Learning should be viewed in a holistic system or program approach that allows learners options and choices. The resultant challenge is to the technology administrator who must consistently match technological advances with evolving institutional, student, and faculty needs.

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FAX: 301-953-0263
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com