Research on Technology and Teacher Education: Current Status and Future Directions

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Within the context of a brief history of information technology in teacher education (ITTE), current research on ITTE is reviewed. It is argued that ITTE research can be categorized into three paradigms: empirical, critical, and interpretive. The need for a clear, multiparadigmatic approach for future work is emphasized. Examples of exemplary work are cited. Conclusions suggest needs for more sharing of information of "islands of excellence" in work on technology in teacher education, more case studies on diffusion of innovation, more emphasis on bias-related findings from critical theory, and more development and dissemination of resources and tools for using technology effectively in teacher education. Recommendations for further work in the area also include emphasizing instructional design (ID) work to create innovations and recognizing the need for grounded, reflective papers on innovative approaches that have been implemented and studied over several years.

☐ Much of the field we call educational technology has links that go back for almost a hundred years, at least to the museum movement in the early part of the 20th century. The museum movement and the success of training and development work during the two world wars were major factors in the development of the field. Educational technology flourished in the 1950s and continues to play an important role in many colleges of education.

The particular subdiscipline of educational technology we will explore in this paper does not have a long history. *Information technology and teacher education* (ITTE) is now a scholarly and professional discipline, but it has only recently become so. During the 1970s and early 1980s, while most educational technology programs continued to emphasize more traditional concepts and skills such as the systematic design and development of instructional materials, a separate group of graduate programs emerged that provided some of the foundations for ITTE. These programs, usually at the master's level but sometimes at the doctoral level, were generally known as "educational computing" programs. They dealt with skills and concepts needed to support the educational uses of computers in schools (and to some extent in business and industry). During the 1970s, the use of computers for education was quite limited, and many programs attempted to be all things to all people. However, as the field developed and the

technology available became more diverse and complex, it became obvious that there was a need for specialization.

While many of the educational computing programs have matured into general educational technology programs, some have elected to specialize in a subdiscipline. One of those subdisciplines is now known as *technology and teacher education* or ITTE. The doctoral program in educational technology at Iowa State University is one example of this type of specialized program.

THE EMERGENCE OF ITTE

In the early 1980s, ITTE was part of the general fields of educational technology and educational computing, and scholarship on ITTE was dispersed throughout the 50 or so journals dealing with some aspect of those disciplines. Journals such as the *Journal of Research on Computing in Education, Computers in the Schools,* and *Educational Technology* all published occasional papers on ITTE. At about the same time, this growing number of ITTE professionals found that existing conferences such as the National Educational Computing Conference (NECC), the American Educational Research Association (AERA), and the Association for Educational Communications and Technology (AECT) no longer met their professional needs.

The International Society for Technology in Education (ISTE) was the first organization to recognize the emerging needs of ITTE, establishing in 1983 a special interest group for teacher educators interested in the use of computers. That same year the special interest group published the *Journal of Computing in Teacher Education,* the first refereed quarterly journal dedicated to scholarly research and professional practice in ITTE. In 1990, the first national ITTE conference was sponsored (www.aace.org/conf/site/) by the organization later named the Society for Information Technology and Teacher Education (SITE). In addition, SITE began publishing the *Journal of Technology and Teacher Education.*

Today, scholars and practitioners have a number of publication outlets for the general field of ITTE. They include the specialized journals, *Journal of Computing in Teacher Education, Journal of Technology and Teacher Education,* and *Journal of Information Technology and Teacher Education,* as well as the *Technology and Teacher Education Annual,* published by the Association for the Advancement of Computing in Education (www.aace.org). In addition to the general journals on technology and education and the journals on ITTE, there are also a number of content specific journals (e.g., *Journal of Computers in Math and Science Education* and *Journal of Computers in Early Childhood Education*) that accept papers related to the support of teachers in those fields. All the general ITTE journals are less than 20 years old, and many of the content-specific journals are even younger. It also should be noted that the two major journals for teacher educators, (a) *The Journal of Teacher Education* (Vol. 47, No. 3), and (b) *Action in Teacher Education* (Vol. XVII, No. 4), each published a theme issue on technology and teacher education in 1996. Scholars who investigate ITTE and consumers of ITTE research have a wide range of options to choose from today.

Another indicator of the emergence of ITTE as a subdiscipline is the pattern of reports from the congressional Office of Technology Assessment (OTA). The original OTA report on technology and education (OTA, 1988) dealt with the entire field. It addressed problems and issues that surround efforts to increase the meaningful use of technology in schools. One area of that report dealt with teacher education. Then in 1995, OTA commissioned a series of studies dealing specifically with technology and teacher education. The ITTE chapter (Willis and Mehlinger, 1996) in the second edition of the Handbook for Research on Teacher Education (Houston, 1990) was originally one of the reports commissioned by OTA for the teacher-education report. Other contractors did case studies of exemplary preservice programs (University of Virginia, University of Wyoming, University of Northern Iowa, and Vanderbilt University) as well as in-service programs in school districts. The final report, "Teachers and Technology: Making the Connection 1995" (OTA, 1995), is available on the Web (www.wws.princeton.edu /ota/). It was one of

the last reports produced by OTA before Congress eliminated the agency.

Even with the growing recognition of the need for work on ITTE, it is interesting to note that the 1200-page *Handbook of Research for Educational Communications and Technology* (Jonassen, 1996) does not have a chapter on technology and teacher education, and the term *teacher education* does not appear in the index of the book. In some universities, there is an established and long-standing rift between teacher education and educational technology that has hindered collaboration and cooperation. While relations have been cool between educational technology programs and teacher education at many universities, there are now numerous examples of universities where this is not the case.

RESEARCH PARADIGMS FOR ITTE

ITTE is a part of educational technology and education; it is also heavily influenced by psychology, particularly educational psychology. Thirty years ago defining the term *research* in an educational or psychological context was not difficult. Research was quantitative, it involved a research design (often control-experimental group or correlational), and it was done to support a particular theory (Willis, Jost, and Wright, 1999). But a growing dissatisfaction with quantitative empirical research spawned other research paradigms. We argue that there are three predominant research paradigms in the field today: (a) empiricism, (b) critical theory, and (c) interpretivism (see Guba & Lincoln, 1994, for a discussion of a similar framework). These paradigms represent the way individuals see the world around them and their relationship to that world. Paradigms or "world views" are above the concerns of data types. Although empirical-research reports are typically quantitative in nature, and critical-theory and interpretivist reports tend to be qualitative, researchers in all three paradigms can use either data type. The greater differences, as we see it, are in what they do with the data and the purpose of the research.

Empiricism

Empiricism, also called positivism, postpositivism, or logical positivism, is based on the assumption that the scientific method is the only proper method for studying human behavior because of its success in the "hard" sciences. Most researchers working from an empirical view believe in an external reality that can be known and quantified. Empirical research then attempts to examine narrowly defined variables in a small sample of a given population in order to generalize findings back to the overall population. Examples of this type of work that have made major contributions to ITTE are the survey research projects of Becker and of Moursund.

Certainly, survey research has played a significant role for ITTE scholars needing an accurate portrayal of *what is* with respect to computer use in schools. The work of Becker (1986a, 1986b, 1991a, 1991b, 1994, 1999) has provided the field with a continuing story of the development of computer use in schools. Becker's early work provided valuable information about teachers' use of computers in classrooms and suggested that integration of computers into classroom learning was an almost painfully slow process. Becker's surveys are recognized as carefully prepared and administered, as well as carefully interpreted. His work has provided a continual update for scholars interested in understanding and changing classroom practices related to computers. In his most recent survey, Becker analyzed the connection between constructivist beliefs, pedagogy, and computer use (1999).

The Milken Exchange on Education Technology sponsored a survey research study focused on technology use in teacher education and carried out by the International Society for Technology in Education (Moursund & Bielefeldt, 1999). The study yielded data from 416 teacher-education institutions around the country. Although some questions about methodological weaknesses have arisen, results suggest that, in general, teacher-education programs do not provide adequate experiences to prepare preservice teachers to use technology in their classrooms. In addition, survey results indicate that a single course in instructional technology does not pro-

vide adequate preparation for preservice teachers to integrate technology into their classrooms (Moursund, 1999).

Some modern empiricists recognize that their studies may not always represent the "real" world accurately. Empirical investigations alone, even when done correctly, could lead the researcher to conclusions that present an incomplete or partial picture of an environment. The goal of empirical research, nonetheless, is to systematically examine aspects of real world samples in ways that inform practice and that are generalizable to broader populations (Smith, 1993).

Critical Theory

Critical theory is an expansion of traditional Marxist ideology to include consideration of factors other than control of the means of production. Critical theorists are sometimes referred to as the Frankfort School because the movement originated at the University of Frankfort. The founders thought that modern societies had within them many power relationships that benefited one group at the expense of another (Smith, 1993). For example, control of newspapers and radio by one class could help that class impose on other classes its views of how things ought to be. Critical-theory research is ideological rather than methodological. It is an effort to make obvious the inequities that are inherent in modern capitalist societies.

Apple (1995, 1993, 1991; Bromley and Apple, 1998) is perhaps the best known critical theorist who writes regularly about issues related to technology in education, including ITTE. His 1991 paper is a good example of the type of conceptual work done by many critical theorists. Apple did not describe in his paper a single study, nor did he summarize the results of a series of individual studies. Instead, he stepped back and took a broad view of the field. He argued that too many of the discussions about technology in education focus on the *how to* questions rather than the *why* questions. He then explored a number of political and economic issues, and discussed in detail whether teaching as a profession will be enhanced and empowered by the advent of technology. He concluded that if current trends continue, the profession may well be disempowered and de-skilled as teaching is redefined as a management job that focuses on keeping the computers running while the machines deliver specific, skills-based instruction to students who are being prepared for boring, demeaning jobs in a capitalist society that views people as resources to be used as the employer sees fit.

Apple's broad-stroke research draws from the methodologies of the historian and essayist as well as the traditional educational researcher. This is a common approach among critical theorists because they are often concerned with larger and more complex issues, such as the study of how integrated learning systems improve the achievement test scores of disadvantaged students. C.A. Bowers (1988) used a similar approach in his paper entitled "Teaching a Nineteenth-Century Mode of Thinking Through a Twentieth-Century Machine." In the paper, he argues that the way personal computers are being used in education reinforces certain types of social interaction and legitimizes certain types of knowledge at the expense of others. Bowers argues that in a computer-intensive learning environment, the role of the teacher as an interpreter, clarifier, and amplifier of cultural knowledge becomes critical because of the bias built into the computer as an educational tool. Essentially, Bowers argues that computer technology was created by representatives of the dominant culture and is an expression of the interests and values of the more powerful subgroups in that culture. For example, because business wants workers with the basic knowledge needed to learn the skills required for certain types of jobs, the computer is more often used to teach those skills than it is to help students develop the basic skills for self-determination (which might at times cause workers to see their interests and those of employers to be incompatible). An excellent annotated bibliography of essays and conceptual papers written from the critical perspective is available on the Web at www.ctf-fce.ca/ctf/restech/critical.htm under the title *Critical Issues in Education and Technology Series No. 1.*

Critical theorists also use more traditional

qualitative and quantitative research methods. For example, Monke (1997) used a detailed case study of the diffusion of technology into the public schools of Des Moines, Iowa, to highlight the significant and serious hidden costs of such efforts to teachers and administrators. A modified case-study methodology was also used by De Vaney (1993) to analyze the gender issues inherent in the popular piece of educational software, *The Oregon Trail.*

A critical perspective was also used by Chisholm and Wetzel (1998) to evaluate computer-supported lessons created by a group of elementary teachers. They found the lessons strong on integration, with a focus on high-level thinking skills. However, Chisholm and Wetzel also found that few of the units made provisions for students whose native language was not English. In addition, very few of the units included collaborative work at the computer. The Chisholm and Wetzel study illustrates what may be an emerging trend in our field. Critical theorists are typically ideological. They expect to find bias, inappropriate power relationships, and other types of domination and subjugation.

Critical theorists have also used several types of quantitative methodology. Chappell (1996), for example, used content analysis to study the amount of violence and competition as well as gender representation in the most popular math educational software.[1]

Chappell's results indicated that 4.2% of the activities in preschool math software were violent, and that 46% of the activities in high school programs were violent. Similarly, none of the activities in the preschool software involved competition against peers, while 31% of the activities were competitive at the high school level. While not widely cited, there is a growing body of literature that supports and extends the findings of Chappell. See, for example, the March 1998 issue of *GREAT* (Gender Relations in the Educational Applications of Technology). See also the report of the American Association of University Women (1991) that synthesized more than 1,000 papers and reports with the title, *Shortchanging Girls, Shortchanging America.*

This body of research suggests the attitude of girls toward computers is positive in preschool but becomes more and more negative over the K–12 years. Chappell believes the amount of violence and competition in software may be one factor in that trend. Her study also found that while 39% of the characters in preschool math software were female, only 13% were female in high school programs. Chappell's work has significant implications for teacher education. She points out that while the averages for each grade level were not encouraging, there were examples of software at each grade level that did not emphasize competition or violence. There were also programs that had many female characters. If preservice teachers become aware of biases inherent in some educational software, they will be better able to make informed choices when they begin their teaching careers.

Some critical theorists have even developed specialized methodologies to study various aspects of educational technology. Robinson, Wiegmann, and Nichols (1992), for example, detailed a *socio-cultural* methodology for evaluating instructional materials. Their guidelines for evaluating materials include a number of questions not normally found in traditional evaluative systems. The implicit, as well as the explicit, political and gender viewpoints represented in the material are specifically targeted for analysis. Critical theorists regularly adapt and revise existing research methodologies to better fit their purposes, but the defining characteristic of critical theory research to date is the focus of the research, not the methodology used. As Nichols and Allen-Brown (1997) put it, "Educational technologists should become more engaged with research about many foundational, essential, provocative, and morally pertinent issues that are largely unconscionably ignored. . . . The issues include societal relations, feminism, and popular culture. Further issues include critical relations of educational technol-

1 Content analysis is used infrequently in studies published in the mainstream instructional technology literature. However, it is much more common in studies about technology and gender that are published in other journals. A Website named Content Analysis (http://www.gsu.edu/wwwcom/content.html) is one of the better sources of information on both content analysis methodology and studies that use the method.

ogy to language, visuals, race, capitalism, the military, politics, ethics, and ecology" (pp. 245–246).

Finally, it is important to note that critics, including other critical theorists, often chastise this paradigm because it often seems "to be aimed at building individual careers by criticizing the work of others, and it emphasizes the ways in which people are oppressed and despairing" (Nichols & Allen-Brown, 1997). The critical theory literature can, indeed, provide only a negative perspective, and far too few examples of positive work have been done from a critical perspective. However, that is changing. More and more critical theorists are taking the initiative and developing approaches to problems in our field that reflect their values and perspectives. Research from the critical perspective in educational technology is appropriate and crucial to our growth. One early proponent of this perspective (Damrin, 1991) argued that if we change the way technology is used in education, technology can become a positive force in a feminist reform of math and science education.

Critical theorists have also used the instructional design (ID) process to create new instructional experiences based on the critical perspective. An excellent example of this is Francis's (1996) work on micro teaching at James Cook University in Australia. Francis was concerned that the traditional form of micro teaching used in preservice teacher-education programs is based on a postpostivist view of knowledge and practice. "It has become passé to claim that the model of teaching as a "technical" process must be challenged. Critical theory and notions of the teacher as reflective practitioner seem to have rendered obsolete the practice of micro teaching in its single skill focus" (Francis, 1996). Francis proposes, however, that instead of eliminating micro teaching, it be reconceptualized as a means of helping students become more reflective and critical professionals. Her paper and the work she has done on a new form of micro teaching are excellent examples of a proactive critical approach to teacher education. There are many aspects of technology use in teacher education that would profit from this type of critical attention.

Interpretivism

The third research paradigm for ITTE is interpretivism. Interpretivism is a philosophy of science that is related to constructivist theories in psychology and to forms of research that are often described as qualitative. The essence of the interpretive approach to research is the position that social science cannot hope to find universal truths about human behavior. The reasons for this are many and varied (Smith, 1989; Willis, Jost, & Wright, 1999) but the end result is the abandonment of a search for lawlike generalizations. That search is replaced by an emphasis on understanding, *verstehen* in German. The realities of social science research are not eternal verities that, once discovered, are true for now and forever. In the interpretivist paradigm, realities are local, transitory, and contextually based.

Interpretivism also holds that realities are constructed by humans in groups. Thus, what is real for one group is not necessarily real for another. This approach to the basic idea of what constitutes meaning and reality leads to a decidedly different approach to research in comparison with other paradigms. There is, for example, much more emphasis on understanding the context of the research since much of the meaning is in the context. Not surprisingly then, experimental research that is done "out of context" in carefully controlled settings is much less important and relevant than "dirty" research done in context. Interpretivists would argue that in empirical research, the technical quality of the research (internal validity) is often more important than whether or not it warrants our attention (external validity). In interpretive research, the most important criterion is *relevance.*

The emphasis on meaning in context leads to acceptance of a wide range of activities that constitute "research." Thoughtful case studies, for example, that might only be useful to strict empiricists as precursors or supplements to a later research study can become a valuable primary source of understanding because they offer rich or *thick* data on a topic instead of the sometimes *thin* data gathered in quantitative studies.

Reflective professional practice papers are also accepted and even welcomed by inter-

pretivists. For example, Wheatley and Greer (1995) used their experience offering teacher-education courses over a two-way interactive television network to develop a series of thoughtful and insightful suggestions for others who are considering offering similar courses. The argument that sources of understanding, such as case studies and professional practice papers, are unacceptable because they are subjective and deal primarily with a particular local context is not accepted by interpretivists. They see *all* social science research as being subjective and as dealing with a local context. This view shifts the responsibility of making decisions about generalizations from the researcher to the consumer. The consumer does not take the research paper as a reflection of universal truths. It is, instead, always the story of one particular setting, told subjectively by the authors. Consumers decide what might be useful as background information as they make decisions in their own context.

The idea that all truth is local breaks down a number of barriers in research. For example, the difference between research and program evaluation melts away because it is based on the idea that program evaluation leads to local truth, while research leads to generalizations that go well beyond the particular setting of the study. Since interpretivists believe that all knowledge is local, there is no need for the distinction.

The emphasis on context also points interpretivists toward what has been termed *participatory* research. Participatory research (Heron, 1996) includes participatory action research and many other forms that break down the wall between the researcher and participants. In this approach there are participants, not subjects, and they may play very active roles in everything from the design and development of the research to the data analysis and write-up.

Viewing research from an interpretivist perspective also removes the stigma research universities often put on ID work. Because ID involves the creation of instructional materials for a particular setting, research universities have often refused to consider ID research. Even when ID work was published and the material distributed nationally, some universities did not classify the work as scholarship. Today that is changing. ID work leads to important outcomes and products, and it often leads to a better understanding of the teaching and learning context. A good example of an interpretivist approach to ID is the work of Tancock and Ford (1996), who were concerned with ways of supporting reflective thinking in preservice teacher-education students. They described the creation of an electronic portfolio system that both facilitated reflection and provided an alternative means of assessing students.

Finally, the interpretivist movement has led to a broadening of the ways research can be reported. The traditional research paper, with details of context and a recognition of the subjective nature of the research (including the authors' biases and background) is still the most common form of reporting. However, many other forms of reporting are also acceptable: a case that is told as a story, a video, a short story or play, a metaphor, a piece of art (e.g., sculpture or painting), and others. An example of an alternative way of reporting research is Norum's (1997) report of observations of the work of two high school teachers who were learning to use a television-based distance education system to deliver foreign language instruction to students in several different schools in the Denver area. Norum used case study methodology, but she reported the two cases in the format of a "nonfictional educational story."

WHAT DO WE KNOW? IT DEPENDS

What we know depends on the paradigm we use. The empiricist paradigm is the most restrictive because it accepts as valid research only studies that meet very detailed criteria. Critical theory is the next most restrictive because it imposes an ideological framework on research. Research identifies local instances of the power and oppression critical theorists know is there because their ideological stance insists it exists. Least restrictive is interpretivism, which accepts that we can learn from many different forms of research.

In order to include findings from each paradigm, we will use the interpretivist perspective to summarize what we know in ITTE today, and

that creates some challenges. Interpretivism does not accept the idea of an external reality we can know. We cannot review the literature and conclude that certain facts are absolutely true. The best we can do is express some of the consensus about ITTE. That consensus may change, evolve, and even go away over the next decade, but it is what we think of as true today. It is impossible, however, to provide a truly comprehensive review of the ITTE research base. Several relatively current reviews of the literature provide useful summaries of research and suggestions for future work.

Literature Reviews

Brownell (1997) selected 28 studies for inclusion in her review of ITTE research from 1990 to 1995. She selected papers in three categories: (a) empirical, (b) model development, and (c) surveys. Brownell noted that much of the research involves studies of teacher attitudes, and she suggested that more empirical studies of the impact of ITTE are needed.

A second review, the OTA study (1995), was a comprehensive look at the status of technology and teacher education. It offered a number of conclusions about the status of ITTE. The study concluded that few universities are doing an adequate job, but that there are exemplary programs at a number of institutions. The ISTE study mentioned earlier (Moursund & Bielefeldt, 1999) suggested that in 1999 there were still only a few universities adequately preparing preservice teachers to use technology. The ISTE work suggests that future work in technology in teacher education should focus on identifying, studying, and disseminating examples of effective technology integration in teacher-education programs.

A third comprehensive review of ITTE research is a chapter in the second edition of the *Handbook of Research on Teacher Education* (Willis and Mehlinger, 1996). This review provides a comprehensive review of the research through 1995 and suggests a number of directions for future research. Instead of suggesting more empirical research, as Brownell (1997) did, Willis and Mehlinger suggest there is a great need for "more field-tested, instructional materials" (p. 1019).

Status of the Field and Attitude Issues

In addition to the large-scale literature reviews, survey research has provided some valuable contributions to our knowledge of ITTE. A number of studies, including several conducted for OTA to support their report on ITTE (OTA, 1995), examined the current status of the field. In general, the surveys report that teachers have positive attitudes about the use of technology in schools, but that teachers are not confident of their ability to use technology in the classroom, and do not think their teacher-education programs prepared them to use technology in innovative ways. These are the results reported by most of the survey studies reported thus far, however, there have been exceptions. Laffey and Musser (1998a), for example, reported that incoming teacher-education students did not appreciate the potential of technology in education and thought that technology in the classroom actually interfered with the student-teacher relationship.

Other survey studies have looked at specific aspects of ITTE. A study by Sheffield (1998) looked at the computer literacy skills of first-year college students and found that most preservice teacher-education students reported only limited computer expertise. However, across the six-year period, 1991–97, there was a steady increase in the level of computer literacy reported. Another type of attitude study involves looking at changes in attitude after technology-related experiences. Many studies (see Willis and Mehlinger, 1996, for a more detailed review of this literature) suggest that completing a computer course improves attitudes toward technology.

There have also been a number of criticisms of attitude and survey research. Brownell (1997) was critical of the emphasis on attitude research. "The research on educational technology in teacher education needs to avoid going in circles and getting lost in the assessment of attitudes towards technology in teacher education programs" (p. 133). Willis and Mehlinger (1996) also

suggested that the emphasis on attitude studies is misplaced. It is not that we do not need additional studies of attitudes toward technology, it is that we need many other types of research as well. Surveying attitudes is a relatively straightforward methodology that is easily implemented. Being easy to do, however, does not mean it is always important as a means of advancing the field. We may not need another attitude study, for example, that shows that teachers have positive thoughts about telecommunications. A much more valuable contribution to the field would be a paper on approaches to facilitate teachers' integration of telecommunications into the classroom, or a paper about policies at the state and local levels that could encourage useful telecommunications integration.

Policy Issues

Policy issues tend to be a somewhat neglected aspect of ITTE and can be approached from any of the three paradigms. Some policy documents deal with the entire field, addressing "big picture" issues and suggesting ways of dealing with perceived problems. Robinson's (1995b) paper on the relationship of ITTE to the United Kingdom's national curriculum is a good example of a paper that addresses policy issues at a national level. In North America, perhaps the best known and most widely cited of the policy publications in the last ten years is the previously mentioned OTA's 1995 report on technology and teacher education. Other policy papers have dealt with one aspect of ITTE. A paper by Woodrow (1998) looked at the general issue of preparing teachers to use technology in the classroom. Her professional practice paper was based on four years of experience with a K–12 school-university collaboration.

Policy issues have also been addressed by developing suggestions based on feedback from groups such as teachers. Fisher (1997) asked 287 technology-using K–12 teachers in Colorado what they thought should be included in preservice programs. Another use of experts to develop policies and procedures was Herring's (1997) study of what school districts should offer in terms of support if they were to encourage constructivist teaching in distance education. Herring selected 12 nationally known experts who were recognized for their work in constructivist approaches to using technology. Results from Herring's study provide us with a body of methods and strategies that can serve as the foundation for creating constructivist-based distance education. Four threads consistently identified by the experts as important or very important to training teachers to enable the design of constructivist-based distance learning environments included: (a) establishing facilitator roles for teachers, (b) embedding assessment within the learning process, (c) creating and facilitating problem-based learning, and (d) creating multiple approaches for knowledge development. Perhaps the most surprising outcome of this investigation was the secondary role of technological tools in the process. Many distance-education training sessions have centered around issues such as time management, classroom management, instructor presence, and presentation issues. The results show that the training should center on the instructional issues first and on the operational issues second.

Diffusion of Innovation

A number of scholars have reported efforts to infuse technology across the entire teacher-education curriculum. Stuhlman (1998) described the work at Louisiana State University that emphasized providing preservice students with models and examples of technology integration and opportunities to use technology in a cooperating elementary school. Stuhlman reports ten brief case studies in her paper that illustrate her proposals. For example, she reports that students who had more contact with technology also supported more student-centered approaches and had more confidence in their ability to be successful teachers.

A paper by Thompson, Schmidt, and Hadjiyianni (1995) described efforts at Iowa State University to diffuse technology across the teacher-education curriculum. The Iowa State University work included several different types of diffusion support. Noting that faculty levels

of need for support were highly individualized, a program using graduate student mentors to work with faculty one-on-one was implemented. This model for diffusing an innovation has been used and expanded by others (Sprague, Koffman & Dorsey, 1998) and appears to be a promising method for work in integrating technology across the teacher-education curriculum.

Studying characteristics of technology in the four teacher-education programs that had been identified as exemplary in the 1995 OTA report, Strudler and Wetzel (1999a) used a case approach. In their work, Strudler and Wetzel provide a detailed description of these exemplary programs and suggest recommendations based on their findings. Acknowledging that successful approaches at one site may not be generalizable to other sites, they provide detailed descriptions so that readers can find the parts of a program that may apply to their own situations. Recommendations emphasize the importance of governance and leadership in colleges, schools, and departments; the need for carefully planned faculty development; and the significance of access issues for colleges and schools of education.

In contrast to the Louisiana State University and Iowa State University papers, which were based on case-study methodology, Brush (1998) used an ID framework to write a paper about the revision of an undergraduate teacher-education course on technology at Auburn University. He described in detail the development process and provided examples of student work and assignments. Still another effort to infuse technology into teacher education was described by Schrum and Dehoney (1998) at the University of Georgia. In this project, preservice teacher-education students were provided Macintosh laptop computers during their professional year. They received training and support, and the faculty supported a number of uses of the computers, including e-mail, discussion groups, and Internet access. Schrum and Dehoney used surveys and open-ended questions to evaluate the project. The research showed that as a result of the training, students were more comfortable with technology, more confident, and more positive about technology in education.

In order to add to knowledge in ITTE, it is imperative that work describing innovations be situated in previous work in the area. Two examples of descriptions of innovations that are carefully grounded in the literature are the work of (a) Boehmer and Waugh (1997) and (b) Goldman and colleagues (Goldman & Barron, 1990; Goldman, Barron, & Witherspoon, 1991). Boehmer and Waugh provided a model of this type of reflective, descriptive work in their article on a teaching teleapprenticeship project that linked university undergraduates with students in K–12 schools in an introductory biology class. Surveys, interviews, and observations were all used as means to describe project experiences.

Goldman and colleagues (Goldman & Barron, 1990; Goldman et al., 1991) described effective sharing of an innovation in their work using hypermedia cases in teacher education. Included are detailed rationale and descriptions of how hypermedia technology is used in content-methods courses at Vanderbilt, as well as evaluation data that suggest specific, positive student outcomes.

Most of the literature on diffusion in ITTE comes from the proponents of the innovation. Much needed are more reports from the teachers who were involved in integrating the innovation into their classrooms. One such study was published by a group of teachers at the University of Alberta (Gibson & Hart, 1997) about their experiences. The teachers reported that preparation before they were to implement the innovation was inadequate and that they did not realize the potential of the technology until they were well into the implementation phase. Additional reports of teacher experiences as they attempt to use technology in the classroom would be very useful. They might be in the form of case studies, as the Alberta study was, or in other formats, such as summaries of journals.

Diffusion in ITTE was the topic of a special issue, edited by Willis, of the *Journal of Information Technology for Teacher Education.* All the papers in that double issue (1996, issues 1 and 2) dealt with diffusion. Some described models in a college of education; others dealt with collaborative projects between colleges and K–12 schools. Willis's (1996) paper provided a framework for thinking about diffusion in ITTE. A much more extensive treatment of that issue was published

by Davis, Kirkman, Tearle, Taylor, and Wright (1996). Davis and her colleagues took the position that diffusion in colleges of education generally occurs as a series of phases that are not smooth and continuous. Robinson's (1995a) paper on change in ITTE is perhaps the most significant one thus far. He argues that conceptions of change and diffusion that are situated solely in institutional and organizational contexts are incomplete because all change is also personal change.

Innovations and ID Studies

An innovation can be anything from a redesign of an existing course to the creation of a multimedia or WWW-based instructional package. The work of Strang (1995) at the University of Virginia on computer-based simulations of teaching illustrates this type of work. Over the past fifteen years, Strang has developed a number of computer-based simulations (e.g., *Teaching Worlds*, 1995), that have been used both for instruction and for research. Current versions of Strang's simulations are sophisticated tools for teaching and learning that are compatible with behavioral, cognitive, and information-processing theories of learning.

A decidedly nonbehavioral approach was taken by Cennamo, Abell, George, and Chung (1996) when they developed a series of case-based interactive videodiscs for use in science methods courses at Purdue University where the goal was to help foster reflective practice. Cennamo and her colleagues used a constructivist approach to ID and constructivist- reflective approaches to teaching and learning.

Innovations may also involve the creation of infrastructure support systems. This last type of activity is illustrated by Robin and Miller's (1998) description of an electronic infrastructure to support teacher education at the University of Houston. The authors describe the creation of a special server for teacher education that was connected to the university network and to the Internet. The authors created a number of special programs for particular needs within the teacher-education program. One program they developed was a user-friendly discussion system for classes. Students could answer questions placed in the system by the instructor or start their own discussion strand. Laffey and Musser (1998b) reported a similar project at the University of Missouri, Columbia, that included the development of software to help students keep reflective journals on-line while they worked in local schools.

A number of recent ID studies have described the process of designing material for teacher education and have also provided a detailed description of the products developed. Jin (1997) developed a Website on constructivist teaching for use in educational technology courses for teachers. Lambdin, Duffy, and Moore (1997) went further. They developed an interactive videodisk on teaching, learning, and assessment in mathematics and then tried it out in a number of courses. This ID work was based on a constructivist model. The material:

> was designed to support teachers through a constructivist or process-oriented learning environment . . . in particular, the sort of environment reflected in models of cognitive apprenticeship . . . and of the reflective practitioner. . . . One of the . . . design strategies was to provide access to multiple, sometimes very different, representations of exemplary (learner-centered, collaborative, problem-driven) practice to aid prospective teachers in understanding that the teaching strategies illustrated should not be seen as practices to be slavishly imitated but, rather, as providing the underpinnings for a conceptual framework to guide practice. (p. 175)

The authors concluded that the package, the *Strategic Teaching Framework-STF*, was effective. The work of this group at Indiana University is one of the best examples of ID work linking theory to practice in a project that involves the creation of support material and the evaluation of that material in use. One interesting and unsuspected benefit of using the material was that it became a common framework for discussing many topics in the course. Because students all saw the videodisk, they frequently used it as a reference point for discussions in class.

Another project at Indiana University (Boone, 1995) also used constructivist foundations. Boone's paper described a televised distance education course for inservice science teachers. In contrast to the traditional talking-

head approach so common in televised courses, Boone created a course that involved discussion and demonstration of innovative teaching strategies which were then practiced by teachers at several sites around the state of Indiana. The class generally began with discussions or demonstrations; then students at different sites were given time to develop similar lessons themselves. During the last part of the class, students at different sites "taught" their lessons for others to see.

Component Studies

There have been a number of interesting component studies in ITTE. One by Powell and Lord (1998) at the University of Georgia looked at the impact of adding a computer-based simulation activity to a preservice field experience. On a survey instrument that measured attitudes toward technology, knowledge of educational technology, and perceived importance of technology in schools, the authors found that students who were involved in a simulation that called for them to make decisions about the use of technology in the classroom had higher scores than did those who did not use the simulation. Another study (Ivers and Barron, 1998) looked at whether pairing students when they learned to use an electronic mail system via a computer tutorial was more effective than working alone and found that it was more effective to pair students.

There are also a number of studies reporting the impact of adding a telecommunications resource to a teacher-education course. Typically, these studies report that the course experience is enhanced by the addition of e-mail or discussion activities. An example of this type of work is Johnson's (1997) study of adding e-mail activities to a reading-methods course. Preservice teachers in the course were linked via e-mail to practicing teachers to help the students "gain a greater understanding of different philosophies of reading through collaboration with practicing teachers across the country via electronic dialoguing" (p. 163).

Another example is Harrington and Quinn-Leering's (1996) work on the use of electronic conferencing activities in teacher-education-foundations courses. In their work, which is based on a critical paradigm, they found that students became more sophisticated in the way they thought about issues when conferencing was added to the course. They also reported that electronic conferencing supported the creation of more democratic communities of discourse in which more students were comfortable participating.

THE FUTURE IN A MULTIPARADIGMATIC ENVIRONMENT

Discussants in the debate about what constitutes research sometimes take on the enthusiasm of religious zealots, but for most of us, the issue is not what is right or wrong, but rather what warrants our attention. As both producers and consumers of research on ITTE, how should we deal with the issue of paradigm? One solution is to pick a paradigm and then both conduct research and keep up with the research done within that paradigm. In this model, research from other paradigms would be ignored. We think that is an inappropriate response for several reasons. First, the foundations for each of the paradigms are flawed (Chalmers, 1982, 1990; Smith, 1989, 1993). None is so compelling that it virtually requires any thoughtful and open person to accept the paradigm. Also, valuable information has been developed by researchers in all three paradigms. Becker's (1986, 1991a, 1991b, 1994, 1999) work from an empiricist framework, for example, helps us understand developing uses of computers in K–12 classrooms. Another example is Pelgram and Plomp's (International Education Achievement or IEA) empirical study on the state of computer use in education (1993), which gathered information about teachers' access to computer hardware and software and how these tools were used in classroom situations. An empiricist framework is not likely to yield the insight about ways in which classroom computer use is shaped by the social context in which it occurs and the resulting gender and equity issues that Schofield's (1995) critical study did, however. And, the rich, thick description of Strudler and Wetzel (1999b, in this issue)

illustrates what can be learned from an interpretivist perspective.

In our opinion, most scholars and practitioners will want to concentrate on doing research within one framework, in part because it takes considerable effort to master the implicit and professional knowledge and procedures associated with each of the three paradigms, but we should all attend to ITTE research from all three paradigms. This is, in essence, Rorty's (1979, 1982, 1991) concept of *democratic pragmatism.* It is a worthy epistemological paradigm in which to frame ITTE research. It acknowledges that all research is subjective in one way or another and proposes that it is the responsibility of any scholar to strive to understand not only work in his or her own personal paradigm but in competing and alternative paradigms as well.

CONCLUSION

There were four main aspects of this paper: (a) the emergence of ITTE as a discipline, (b) paradigms for research and development work in ITTE, (c) what we "know"[2] about ITTE and (d) current research needs in the field. Using a multiparadigmatic approach, we pulled together some of the main threads of *what we know.* We know, for example, that most teacher-education students have very positive attitudes toward the use of technology in education but are far less confident about their ability to actually use technology. We know that teacher-education faculty also have positive attitudes toward technology in education, but many do not feel they have a strong background in actually integrating that into the teacher-education courses they teach. We also know that most preparation for preservice teachers in the area of technology remains inadequate.

We know that there are isolated examples, *islands of excellence,* that illustrate what can be done in ITTE. The diffusion rate, however, is fairly slow at this point, and a major focal point for ITTE research could be on the process of change and diffusion. While not specifically about ITTE, the work of change theorists and diffusion of innovation scholars such as Rogers (1995), Hall and Hord (1987), and Fullan (1991) has a great deal to say to us, as do detailed case studies of diffusion in ITTE. We need more detailed case studies on the process of change—how it is handled and how it occurs.

We also need more information on innovations, from the undergraduate major in educational computing at Iowa State University (Schmidt, 1997) to the Internet-based cases at the University of Virginia (Bronack, 1998). How do these and other innovations work? How were they created? What steps were taken to encourage participation and use? And, perhaps most important, how will they be disseminated so that other teacher-education programs can use them if they wish?

The two needs noted thus far, (a) case studies of diffusion efforts, and (b) information on innovations that have been developed and are in use, are good fits with the interpretive paradigm. The need for teacher educators and preservice teachers to become enlightened about the biases in technology use today fits the critical perspective best. We know that much of the educational software available is more appealing to boys than to girls (American Association of University Women, 1992). Perhaps there are other biases that are based on gender, social class, and racial or ethnic background. Critical research can help make those apparent to us, and point to ways of readressing the problem.

Empirical research has already contributed significantly to the field. The surveys of Becker (1986a, 1986b, 1994) alert us to trends in patterns of use in K–12 schools. The ISTE (Moursund & Bielefeldt, 1999) and OTA (1995) survey data keep us updated on the current status of technology use in teacher education. There will always be a need for additional surveys of the current condition in ITTE because times and contexts can change radically in a short period of time.

Empirical research has also attempted to contribute through control group–experimental group studies that compare one form of teaching and learning to another. The purpose is generally to support one theoretical framework over another (e.g., constructivism over behaviorism).

2 The term *know* is used here to mean group consensus rather than any sort of enduring or absolute truth.

We do not believe the studies in this tradition are likely to accomplish that purpose. There are too many variables, too many differences between the groups, and too little commonality across all approaches termed behavioral or constructive to allow us the luxury of broad generalizations. However, it is worthwhile to think of these studies as stories about the local use of an innovation. If the control-experimental aspect is de-emphasized and considerable detail is provided about the local context in which the work was conducted, then the understanding that readers develop from such a study can be quite valuable. The same logic applies to studies of components, such as the addition of an electronic conferencing system to a foundations course (Harrington, 1997). Harrington's work is from a critical perspective. Empirical (and interpretive) studies of the impact of the component, while rare, are also much needed.

Current ITTE work needs to provide a grounded, rich, and thick description of the development of cognitive tools for teacher education. The movement of ITTE into emphasis on integrating technology into teacher-education curriculum has also altered the type of research needed to inform the field. In the early years, empirical and survey research describing the effects of programming and computer-literacy experiences and courses on students were common. Today, information about student and faculty experiences with, and attitudes about, computers are no longer as relevant. Later phases of ITTE have been influenced by an emerging belief that computers will not be used to deliver information to students and reinforce traditional methodologies in schools but will be used as cognitive tools to support critical thinking and model creation (Dede, 1987). Thus, one of the major challenges for ITTE researchers is to create and study uses of the computer as a cognitive tool to expand and enhance educational experiences, both in technology courses for teacher educators and throughout teacher-education programs.

Finally, while there are a number of reports about the creation of resources for ITTE, there are far fewer in ITTE than in most areas of higher education. Davis's (1998) work at Exeter University in England illustrates how a team can create a series of video cases preservice students can study. Work on video cases is also underway at Cleveland State University (Abate, 1993; Hannah, 1995), Iowa State University (Kurth & Thompson, 1998) and Vanderbilt University (Pelligrino and Altman, 1997). Although there are a number of research papers published, there are very few cases available for use in teacher-education courses. The creation of instructional packages, course plans, multimedia support, cases, Internet resources, and many other forms of innovations is a major need in the field. An even greater need is the creation of a dissemination system that makes the resources easily available to other teacher educators. A few national organizations (e.g., AACE, SITE) have taken the lead in making available a series of video cases and curricular materials such as Brent's (1998) simulation, First Day of School. Much more, however, needs to be done, in terms of both creation and dissemination. Reports of the ID process (developmental research) that lead to the creation of innovations are also needed.

To summarize, it seems clear that the major research paradigms in education can all contribute to the advancement of scholarship in the growing ITTE discipline. Six major needs should guide our multiparadigmatic work over the next few years:

1. Current Status Studies
2. Diffusion of Innovation Studies
3. Program Innovation Studies
4. ID Studies and Products
5. Biases of Technology Studies
6. Component Studies

As the study of ITTE matures, it is important that researchers work to disseminate both their materials and findings. Researchers also need to build their tools and materials so that they can be easily shared with others. The growing body of research and tools in ITTE suggests the need for some type of clearinghouse to make information and software easily accessible to teacher educators. The growing community of ITTE researchers and developers must ensure that their work is providing maximum influence on expanding and enhancing the use of technology to improve teacher education. □

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