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The Use of Technology in the Delivery of Instruction: Implications for Accounting Educators and Education Researchers

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ABSTRACT: The twofold purpose of this paper is to offer recommendations to accounting educators regarding educational technology (ET) delivery modes, and to stimulate accounting education research efforts in the area of ET. Drawing from behavioral and cognitive theory, as well as educational research on the impact of technology on learning, this paper reports and discusses the current state of research in ET. Next, ET research and accounting technology research are reviewed and classified into five types: (1) evaluation research, (2) media-comparison studies, (3) intra-medium studies, (4) aptitude-treatment interaction studies, and (5) alternative research designs. We provide practical guidelines to accounting educators and theory-based suggestions to accounting education researchers with regard to ET and its potential impact on student learning. Finally, we offer some directions for future accounting ET research.

INTRODUCTION

The accounting literature offers relatively little research on the pedagogical benefits of using technology to deliver instruction. On the other hand, educational technology (ET) research in the academic domains of education and psychology is quite extensive. What does the research from education and psychology reveal? How can accounting educators and researchers leverage on the work performed in other academic domains? This paper proposes to answer these questions and, in doing so, offers much needed guidance to accounting educators and researchers regarding the use of ET in the classroom.

The twofold purpose of this paper is to offer recommendations to accounting

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educators regarding effective ET delivery modes and to stimulate accounting education research efforts in the area of ET. This paper enhances extant accounting education literature in two important ways. First, we extend Rebele et al. (1998) by expanding the ET framework Rebele et al. (1998) supplies to a more comprehensive review and analysis of ET research. Second, we provide practical guidelines to accounting educators and theory-based suggestions to education researchers with regard to ET and its potential impact on student learning.

The remainder of the paper is organized as follows. In the upcoming section we clarify and classify ET terminology. Next, we define five types of ET research studies. Then we elaborate a progression from behavioral to cognitive psychology inherent in the five types of ET research. Next, we discuss the interplay between media and learner attributes. Then we offer a literature review of current ET studies. Finally, we present implications for accounting educators and researchers.

CLARIFYING AND CLASSIFYING EDUCATIONAL TECHNOLOGY

Novices and incidental readers in the area of ET are often confused by the terminology used by educators and researchers. What is included under the umbrella of "educational technology"? Does ET refer to the use of spreadsheets in an assignment, or perhaps the use of PowerPoint to deliver a lecture? This section clarifies ET terminology and classifies various types of ET.

Understanding the different types of ET gives educators and researchers a clear picture of the domain of ET and its constituent parts. Rebele et al. (1998) classify ET into two broad categories: (1) computer-based learning (CBL), and (2) other technologies.[1] CBL can be subdivided further into computer-assisted instruction (CAI), computer-assisted teaching (CAT), computers for research (CFR), and computers for computing and processing (CCP). The category "other technologies" consists of audio, still pictures, television and film, distance learning, and hypermedia. Table 1 provides examples of each of these ET types.

Just as it may be difficult to separate all the different types of ET, it can be daunting to distinguish among different approaches to ET research. Accordingly, the next section offers assistance in this regard by classifying ET research into five categories. Such a classification may help educators and researchers to see the "big picture" of ET research.

TYPES OF EDUCATIONAL TECHNOLOGY RESEARCH

In a comprehensive review of ET, Thompson et al. (1992) categorize ET research along five dimensions: (1) evaluation research; (2) media-comparison studies; (3) intra-medium studies; (4) aptitude-treatment interaction studies; and (5) alternative research designs. Their classification of ET research is useful, as it offers some clarity to an otherwise confusing stream of educational research.

[1] There has been some controversy involving terminology related to technology use in education. For example, the terms CAI (computer-assisted instruction), CBI (computer-based instruction), CBL (computer-based learning), CBE (computer-based education), and CAL (computer-assisted learning) all have been used to describe educational applications of computer technology (Thompson et al. 1992). Because CBL appears to be gaining in popularity and is considered more general (Thompson et al. 1992), CBL is used in this paper as the broad category encompassing several subcategories of computing technology.

TABLE 1
Educational Technologies by Type

Computer-Based Learning (CBL)				Other Technologies				
Computer-Assisted Instruction (CAI)	**Computer-Assisted Teaching (CAT)**	**Computers for Research (CFR)**	**Computers for Computing and Processing (CCP)**	**Audio**	**Still Pictures**	**TV and Film**	**Distance Learning**	**Hypermedia**

• Drill and practice
• Tutorials
• Intelligent tutorials
• Simulations
	• Electronic transparencies
	• Multimedia presentations
		• CD-ROM
		• Internet-based research (See "Hypermedia")
			• Spreadsheets
			• DSS, ES
			• Tool software, including word processing, data-base managers, telecommunication software, graphics packages
			• Accounting packages
			• Statistical analysis packages
				• Computer-assisted language learning (CALL)
				• Audio tapes, cassettes, and CDs
					• Overheads
					• Drawings
					• Photographs
					• Filmstrips
						• Video
						• Instructional film (moving)
						• Traditional one-way instructional television (live or videotape)
							• Interactive TV
							• Virtual classroom
							• Satellite classroom
							• Web-based distance learning
							  • Interactive chat
							  • Asynchronous delivery
								• HyperCard
								• Interactive multimedia
								• World Wide Web

Evaluation Research

Evaluation research is concerned primarily with testing the extent to which a new medium has an effect on student learning. The research question of interest in this type of study is: "Can people learn from messages presented by this medium?" (Thompson et al. 1992, 13).

To determine the impact of a new medium on learning, evaluation studies typically focus on the "technical perspective" of the new medium. Thompson et al. (1992) discuss this perspective and the theories that underlie evaluation research, including the Shannon-Weaver Communication Model (Shannon and Weaver 1949). A technical perspective highlights the medium itself and identifies the unique characteristics or attributes of the particular medium under investigation. Communication theories such as the Shannon-Weaver Communication Model are the primary source of theory for this line of research. The Shannon-Weaver Communication Model holds that a message is encoded and transmitted via a communication channel (e.g., some technology-based medium) to a receiver, who decodes the message. Evaluation research attempts to identify those attributes of a medium (i.e., communication channel) that best support learning (Thompson et al. 1992).

Thompson et al. (1992) note that with the introduction of a new medium, an evaluation study is typically the first type of inquiry performed. For example, with the advent of radio, television, and computers, early media studies attempted to identify whether learning was enhanced, diminished, or unaffected as a result of using these new technologies in classroom settings. Studies such as those by Woelfel and Tyler (1945) and Chu and Schramm (1967) regarding the effectiveness of radio and one-way television in the classroom generally concluded that under favorable conditions these media could be efficient and effective in delivering instruction (Thompson et al. 1992). With the arrival of computer technology, early computer-media studies attempted to determine whether learning could be enhanced through the application of computer technology. In often-cited meta-analysis, Kulik and Kulik (1986) synthesize the results of 101 computer-based education studies and conclude that increased learning through the use of computer technology can occur (Thompson et al. 1992).

In summary, most evaluation research has found that learning can take place with any technology-based medium (Thompson et al. 1992). Upon concluding that a given medium can positively impact learning, most ET research has then progressed to the next type of study, media-comparison, in which the central research question becomes: "How does this medium compare with others or with conventional instruction as a method of instructional delivery?"

Media-Comparison Studies

Media-comparison studies have been the most prevalent type of research in ET. There have been literally hundreds of media-comparison studies, beginning in the early 1900s. According to Thompson et al. (1992), these studies, which also employ a technical perspective, seek to compare one medium to another or to conventional instruction (which is itself considered a medium) to determine which is "better" for student learning (i.e., which medium results in higher post-test scores on comprehension and recall).

However numerous media-comparison studies have been

questioned. The early 1980s saw a period of intense debate on the validity of media-comparison studies, which have been criticized for faulty assumptions, lack of methodological rigor, and lack of consistent findings (Thompson et al. 1992). The debate reached a high point with Clark (1983, 445), who provided the following famous analogy likening the use of instructional media to a truck that delivers groceries:

> The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in nutrition....Only the content of the vehicle can influence achievement.

This analogy has come to be known in ET circles as the "mere vehicles" argument. Cobb (1997) asserts that Clark's (1983) "mere vehicles" analogy is probably the most widely quoted and debated statement in ET research. Since Clark (1983), the prevailing theory of educational scientists is that media-comparison studies asking the question "Which medium is better or more effective?" are confounded with other salient factors, such as medium and method, medium and novelty, or medium and amount of effort invested in instructional design (Cobb 1997). For example, Cobb (1997) asserts that early research comparing instructional television to face-to-face instruction is confounded by the effect of novelty. The same novelty effect is also attributed to early research in the area of computer-based instruction.

Methodological problems have also plagued media-comparison studies. Seels et al. (1996) reports that Stickell (1963) analyzed 250 television media-comparison studies and found that only ten of the 250 studies were methodologically sound, since they employed appropriate randomization of subjects, they controlled for covariates, and they tested the assumptions underlying the statistical tests. Of these ten studies, none reported statistically significant results.

Media-comparison studies are thus generally considered to be uninterpretable. Thompson et al. (1992, 16) note, "The literature clearly demonstrates that for every study that shows the new medium is better, another study shows the opposite." Hence, the focus has since shifted to intra-medium studies that investigate independent variables other than the medium itself.

Intra-Medium Studies

Intra-medium studies seek to compare alternative implementation approaches for a particular medium. The research question of interest for intra-medium studies shifts from a comparison of one medium to another to "Which are the most effective instructional approaches using this medium?" (Thompson et al. 1992, 16). These studies are designed with the instructional approach, not the medium itself, as the independent variable (Thompson et al. 1992).

Thompson et al. (1992) cite King and Behnke (1989) as an example of intra-medium research on the effects of speech compression on learning. Speech compression refers to the difference in lecture rates of the average instructor (about 100 words per minute), as compared to the average speed of thought for college students (400 to 800 words per minute) (Short 1977). A rate-controlled speech compressor can speed up or slow down a tape-recorded lecture, according to the students' preferences. King and Behnke (1989) investigated the effects of varying levels of time

compression on several variables, including student comprehension of the instructional material presented. Their study represents an intra-medium study because the treatment is the level of speech compression (Thompson et al. 1992).

Marchionini and Shneiderman (1988) studied what type of task is appropriate in a hypermedia context. They concluded that hypertext is more suited to browsing as compared to retrieving tasks. Their study represents an intra-medium study because the variable of interest is how to use the medium more effectively for instructional purposes.

Other types of intra-medium studies focus on the manipulation of medium attributes to enhance learning. For example, some multimedia studies examine the amount of text or graphics placed on a screen. Similarly, much distance-learning research, e.g., Jayasinghe et al. (1997), examines the manipulation of other medium attributes, such as the effect of camera angle and monitor placement on student learning.

While intra-medium studies have yielded interesting and valuable insights to researchers, many of these studies fail to incorporate important learner characteristics, or aptitudes, that may influence learning (Thompson et al. 1992). On the other hand, aptitude-treatment interaction (ATI) studies, the fourth type of study examined in this paper, do consider learner characteristics and how they interact with media attributes. Thus, ATI studies represent an incremental improvement in experimental design in ET research.

Aptitude-Treatment Interaction Studies

Studies that seek to understand the interaction between the learner and the medium are known as ATI studies. These studies have as their ultimate goal the adaptation of the instructional method to the individual, based on the individual's aptitude (Thompson et al. 1992).

What is meant by the term "aptitude"? Cronbach and Snow (1977) define aptitude as "any characteristic of a person that forecasts his/her probability of success under a given treatment" (in Thompson et al. 1992, 17). Thompson et al. (1992, 17) define ATI as:

> ...[as] a result of a particular treatment, individuals at one end of an aptitude variable perform at one level on a criterion measure, and individuals at the opposite end of an aptitude variable perform at a significantly different level on the criterion measure.

ATI research also includes an examination of the interaction between media attributes (e.g., print text vs. multimedia presentation) and learner aptitudes. For example, a student who is deemed to be a visual learner with high visual literacy may benefit more from a multimedia presentation than a student with relatively low visual literacy. On the other hand, a student who has relatively high verbal processing ability may benefit more from reading the material in a textbook (Thompson et al. 1992).

Accounting educators and researchers can learn a great deal from ATI studies, as research findings and implications offer rich practical and theoretical guidance concerning the contingent nature of learning vis-à-vis ET. That is, the extent to which enhanced learning occurs depends on a complex set of interactions among learner and ET attributes.

Alternative Research Designs

The fifth category of ET research,

alternative research designs, is a catch-all for all other types of media studies that do not fit into one of the above four categories. The most prevalent type of research in the category called "alternative research designs" is naturalistic research. Thompson et al. (1992, 19) cite Neuman (1989) in noting that while empirical research seeks to explain cause-and-effect phenomena, "naturalistic research attempts to describe a phenomenon as it occurs in its natural setting to draw inferences that have explanatory value." Naturalistic research may be thought of as the opposite of a laboratory setting (Thompson et al. 1992). While laboratory experiments seek to provide strong internal validity with identifiable cause-and-effect linkages, they are often weak on external validity, or generalizability outside the laboratory environment.

Cunningham (1986) cites case studies and ethnographic studies as naturalistic research examples (Thompson et al. 1992). For example, a case study following one student's experience with distance education (i.e., learning via telecommunication methods) would be considered a naturalistic study, as would a case study comparing Chinese students' perceptions and behaviors related to a particular medium to American students' perceptions and behaviors.

Given that most academic research in the United States traditionally follows the positivist-empiricist paradigm, relatively few naturalistic studies are conducted because they are the antithesis of the positivist-empiricist perspective. Hence, although naturalistic research is valuable in many ways, it is difficult to find large numbers of published ET studies using naturalistic research designs.[2]

Implications for Researchers and Educators

Of the five types of media research, the most promising areas are intra-medium studies, ATI studies, and naturalistic studies (Thompson et al. 1992). Intra-medium studies may further our understanding of how a medium can be used most effectively in classroom instruction. How dense should text be on a multimedia presentation? Where is the best place for a camera to be placed in a distance-learning study? These are the types of questions that can be answered through intra-medium research. Educators can then use this information to design and deliver more informative and effective instruction using these technologies.

ATI studies have enormous implications for instructional design. ATI studies can determine whether a specific instructional method facilitates or inhibits learning for students with particular aptitudes (Thompson et al. 1992). By understanding which learner attributes are important, educators can adapt and target certain instructional techniques to specific types of learners.

Naturalistic studies that focus on small subject groups or individual case studies can also assist educators in learning how to adapt instruction to best meet the needs of individual learners. While the generalizability of naturalistic research is problematic, researchers

[2] According to Birnberg and Shields (1989), behavioral research in accounting focuses on observation of people either in laboratory settings or in a field experiment. Thus, naturalistic research is somewhat more common in behavioral accounting research. This is different from other research schools in accounting, such as analytical research, where expected behaviors are modeled, given certain conditions and circumstances. Similarly, capital markets research examines archival data, and not individual or group behaviors (Birnberg and Shields 1989).

can learn a great deal about the complex interactions among learners, technologies, and settings through field-based investigations.

The five types of ET studies reflect a changing theory base. For example, while evaluation and media-comparison studies have relied primarily on behavioral theory, intra-medium, ATI, and naturalistic studies have been based largely on cognitive theory. If accounting researchers are to develop sound research designs and draw valid inferences in their ET research endeavors, it is important to understand the role that psychological theory has played in the progression of ET research. It is also important for accounting educators to be aware of salient psychological theory related to the use of ET, as such knowledge can help them to better understand the potential learning impact of different types of ET, and to more judiciously apply ET in the classroom. Accordingly, the next section discusses the two most prominent theoretical perspectives that have been instrumental in shaping ET research: behavioral and cognitive theories.

THE ROLE OF BEHAVIORAL AND COGNITIVE THEORY IN EDUCATIONAL TECHNOLOGY RESEARCH

Behavioral and cognitive theories have often been used as the underlying psychological foundations for ET research. In the area of psychology, behavioral theory was articulated and developed before cognitive theory. Correspondingly, earlier studies in ET were largely based on behavioral theory while later studies have been primarily supported by cognitive theory.

Behaviorism

Behaviorism has had a huge impact on ET research (Thompson et al. 1992). A basic tenet of behaviorism is reinforcement theory, which uses both positive and negative reinforcement following a stimulus to influence a change in behavior. Thompson et al. (1992, 9) state:

> Small "chunks" of information should be presented by lessons, and students should be reinforced positively when success at learning is demonstrated. This means that interactive learning between the student and the medium is critical.

The emphasis in behaviorism is on manipulation of controllable variables to achieve a desired, quantifiable outcome. Hannafin and Rieber (1989) note that by *a priori* identification of the desired outcome, the observable response becomes the focal point of learning sessions.

Another major tenet of behaviorism is preassessment of a learner (before any instruction occurs) to accurately gauge what is learned by the application of the technology. Behaviorists believe that learners should be placed at an instructional level at the point where they can be expected to perform at 90 percent of potential competence. New material is presented and drilled upon until it is mastered at the 90 percent level (Thompson et al. 1992). Commensurate with behavioral theory, the stimulus (new material) and reinforcement (positive or negative) cycle begins at the student's preassessed level and continues in increments until the 90 percent level is achieved.

Evaluation and media-comparison studies rely primarily on behaviorism, thus ignoring the individual attributes that influence student learning. On the other hand, cognitivism focuses on how learners mentally process instructional materials.

Cognitivism

Beginning in the 1970s, a dramatic paradigm shift occurred away from

behaviorism toward cognitive theory as the foundation for ET research (Clark and Salomon 1986). Researchers became aware that the study of media attributes in isolation was an incomplete research design. Clark (1983) suggested that the study of media as an independent variable in and of itself is insufficient; rather, he emphasized a necessary shift toward examining the interaction between the media and the learner. Accordingly, cognition became the theory of choice, and the quest was to identify learner variables that mediate learning and to understand the mental processes that occur within the learner. Thus, since the 1970s, intramedium, ATI, and naturalistic studies—most of which are fundamentally rooted in cognitivism—have become prevalent (Thompson et al. 1992).

Educational psychologists largely approved this paradigm shift and encouraged research in this direction, although they did not advocate discarding behavioral tenets altogether. Hannafin and Rieber (1989, 98) summarized the interplay between behaviorism and cognitivism as follows:

> Behaviorism and cognitivism offer tools that, taken eclectically, can strengthen lesson effectiveness and understanding of the learning process....It is apparent that both behavioral and cognitive influences play important roles in designing instruction. A reasonable plan for the design of instruction must reflect a balance among design influences, and must be based in an overriding framework both for how individuals process information and for the potential to manipulate instructional methods and messages.

Accordingly, researchers should consider the interaction of media attributes with learner attributes in instructional design, paying attention to both behavioral and cognitive influences. Phye and Andre (1986) juxtapose behavioral and cognitive theory on several levels, as reflected in Table 2.

If educators and researchers are to make judicious choices regarding the specific type of ET to employ in a given circumstance, it is important that they understand how and why certain media attributes differentially affect individual learners. In this light, the following section discusses the interaction of media and learner attributes.

THE INTERPLAY BETWEEN MEDIA AND LEARNER ATTRIBUTES

The attributes of various media have played an important role in both behavioral and cognitive theory. In particular, two key media attributes have received a great deal of attention—transmission mode and learner control. These two attributes are presented next.

Media Attributes

Cognitive learning theory has long held that the degree of interactive participation by the learner is highly influential in enhancing learning outcomes. Interactive participation heightens the learning experience because the student actively participates in understanding and interpreting the learning environment (Thompson et al. 1992). This theoretical perspective on learning indicates that ET is likely to be most effective if it provides for a dual exchange between the technology and the learner. In order to identify whether a given technology-based medium possesses this dual-exchange capability, one must examine the medium's transmission mode.

An asynchronous transmission mode involves a one-way message stream from the technology to the learner. A synchronous transmission mode embraces the learner in dynamic

TABLE 2
Comparison of Behavioral and Traditional Cognitive Theories of Learning and Cognition

Behavioral Learning Theory	Traditional Cognitive Theory
1. Learner is seen as passive and reactive to environment.	1. Learner is seen as active and mastering the environment.
2. Learning occurs because of associations among stimuli or between stimuli and responses.	2. Learning occurs because the learner actively tries to understand the environment.
3. Knowledge consists of whatever pattern set of associations has been learned [sic].	3. Knowledge consists of an organized [sic] of mental structures and procedures.
4. Learning is the acquisition of new associations.	4. Learning consists of changes in mental structure brought about by mental reasoning.
5. Prior knowledge influences new learning primarily through indirect processes, such as positive or negative transfer because of similarity of stimuli between situations.	5. New learning is based on using prior knowledge to understand new situations, and changing prior knowledge structures to deal with new situations.
6. Discussion of the activities of the mind is not permitted.	6. Discussion of activities of the mind is the central issue in psychology.
7. Strong experimental research tradition. Theories can only be verified through experiment.	7. Weak experimental research tradition. Observational research, thought, experiments, and logical analysis can be used.
8. Education consists of arranging stimuli so that desired associations are made.	8. Education consists of allowing/encouraging active mental exploration of complex environments.

Sources: Phye and Andre (1986). Reproduced in Thompson et al. (1992).

two-way message exchanges by providing a means by which the learner can communicate with the medium. Hence, ET that is static (i.e., asynchronous) in nature necessitates less learner interaction than ET that is interactive (i.e., synchronous). Accordingly, learning is expected to increase through the use of interactive ET.

A second medium attribute is the level of learner control provided by the technology. While some technologies provide for the computer program to make choices as to when and how much feedback is received and what the next step should be (program control), other technologies allow the student to make those choices. For example, an Internet-based research project will permit the student to choose which hyperlinks to follow. Likewise, a CD-ROM-based research project will give the student control as to how to next proceed. A tutorial may allow the student the option of receiving an explanation when choosing the wrong answer. These are all examples of learner control, which is fundamentally rooted in behavioral theory (i.e., stimulus and response).

A large body of research exists in the educational psychology literature regarding learner control, and the findings are somewhat mixed. Hannafin and Sullivan (1995) note that while some findings indicate students learn more effectively when learner control is present (e.g., Kinzie et al. 1988; Gray 1987; Ross et al. 1989), other findings indicate that in complex instructional assignments or in situations where students lack prior knowledge of the subject matter, the presence of learner control can actually diminish student learning (Carrier 1984; DiVesta 1975; Steinberg 1977; Tennyson and Rothen 1979).

Recent research provides evidence that the interaction between individual learner attributes and learner control determines the extent to which learning occurs. For example, Freitag and Sullivan (1995) find that when learners' preferences are matched to the amount of instruction they receive prior to beginning a computer-based learning (CBL) exercise, subjects who receive an amount of instruction that corresponds to their predetermined preferences record higher post-test scores, spend less time in completing an assignment, and reflect more positive attitudes toward CBL. Pridemore and Klein (1991) find that giving subjects learner control over the type and timing of interaction improves student scores relative to a control group. Young (1996) finds that students who possess high self-regulated learning strategies perform better in a learner-control environment than students with low self-regulated learning strategies. Thus, the extent to which learning is improved by the use of ET depends on the interaction between learner control and learner attributes.

Learner Attributes

This section discusses salient learner attributes that have been found to interact with media attributes. Thompson et al. (1992) note that understanding how learners' cognitively process instructional materials (i.e., how they acquire, organize, store, and relate instructional materials) is a critical issue in determining the type of ET to use in a given circumstance. What are the key attributes related to a learner's cognitive processing, and which learner attributes are the most important with respect to instructional design and ET research? This section addresses these questions. A number of learner attributes, suggested by cognitive theory, are expected to affect learning, including prior knowledge, motivation,

mental effort, and individual learning styles.

Prior Knowledge

Park and Hannafin (1993) state that the most powerful influence in determining the extent to which learning occurs is the learner's related prior knowledge. According to cognitive theory, an individual's overall knowledge set is represented by various schemas, or organized networks of prior knowledge (Norman 1982). Learning occurs when individuals are able to imbed new information into existing schemas and create meaningful relationships among schemas. Hence, the extent to which new information affects learning depends on the learner's extant knowledge of the subject matter.

Motivation

Motivation has been studied from many theoretical perspectives, including expectancy theory, equity theory, goal-setting theory, attribution theory, and schema theory. Taken as a whole, these theories suggest that motivation comprises three factors: the choice to perform a task, the level of effort applied during performance of the task, and the persistence of effort in performing the task (Campbell and Campbell 1988; Ilgen and Klein 1988). If environmental and behavioral constraints are held constant, an individual's level of effort and persistence can compensate for a relatively low level of prior knowledge (Libby 1995). Libby (1995) presents empirical evidence that, holding prior knowledge constant, highly motivated individuals can outperform their less motivated counterparts.

Education researchers recognize that a learner's motivation level can affect learning. For example, Hannafin and Rieber (1989) suggest that highly motivated individuals demonstrate increased task perseverance and willingness to seek additional instruction, and are inclined to more deeply process lesson content. Hence, motivation is considered to be a key factor in determining the amount of learning that occurs with various education technologies. Because mental effort is generally considered to be one of three subcomponents of motivation, researchers in ET have focused a great deal of attention on this particular subcomponent.

Mental Effort

Students who are highly motivated tend to expend greater mental effort, while students who are less motivated tend to expend less mental effort (Hannafin and Rieber 1989). In the area of ET research, mental effort has been linked to students' perception of technology as easy or difficult to use. For example, Salomon (1984) assigned students to television and print media treatment conditions. He then studied the relationship among the students' preconceived attitudes regarding the ease or difficulty of television vs. print media as a means of delivering instruction, self-reported amount of mental effort, and achieved test scores. Students who received the print treatment indicated higher preconceptions of difficulty of use, reported increased mental effort, and achieved better test scores when compared to students in the television treatment group. Cennamo et al. (1991) conducted a similar investigation using interactive video, instructional television, and commercial television as the delivery media. Their research findings also indicate a positive relationship among the perceived difficulty of use, amount of mental effort expended, and post-test scores. Together, Salomon (1984) and Cennamo et al. (1991) suggest that higher levels of mental effort can improve learning.

Learning Styles

Cognitive theory contends that learning is optimized when an individual's learning style is congruent with the learning task. One example of learning style research is found in Carlson (1991), who investigated the relationships among an individual's indicated learning style, content scores, observation skill scores, overall satisfaction, and attitude toward learner control of instruction. Using a learner survey, Carlson (1991) classified students as either "deductive learners" (i.e., those who prefer very clear step-by-step directions) or "inductive learners" (i.e., those who prefer to create their own concepts after consideration of several examples and fact patterns).[3] Students then received eight hours of either deductive or inductive instruction. Carlson (1991) reported that learners whose indicated learning styles were congruent with the learning task attain higher post-test scores than students whose learning styles were mismatched with the task. Carlson's (1991) research findings support the assertion that learning style is an important learner attribute that should be considered in instructional design.

Although learning style is undoubtedly an important learner attribute to consider in instructional design, little research on the integration of ET and learning style exists. More research is needed to identify which technologies are more suited for a particular learning style.

It is important that accounting educators and researchers fully understand and appreciate past ET research, as the knowledge gained from such studies suggests what future ET-related endeavors should be pursued. Accordingly, the next section presents a review of ET studies, by ET type, that have been published over the past five years.

A REVIEW OF CURRENT EDUCATIONAL TECHNOLOGY STUDIES

To assess the current state of ET research, we conducted a literature search to identify empirical and theoretical media studies published over the last five years. The primary sources searched were *Educational Technology Research and Design* and the *Handbook of Research for Educational Communications and Technology*. The search revealed 24 ET studies. Table 3 categorizes these studies into the framework previously presented in Table 1. Of the 24 studies, seven are in the area of distance learning, while 11 are in the area of hypermedia. This concentration of studies reflects the current state of computer technology, with distance learning and hypermedia being topics of recent, intense interest to educational researchers. Following is a review and discussion of these studies by type of technology.

Computer-Assisted Instruction Studies

Three studies involve CAI. Schwartz et al. (1999) describe the integration of an intelligent tutorial system (ITS) into an educational psychology course. An ITS functions much like an instructional expert system, with a user interface, an expert supplying domain expertise, a learner model that provides feedback and guidance to the student, and a pedagogical model that contains knowledge needed for making decisions about the tutoring tactics

[3] Carlson (1991) does not specifically name the learner survey. She describes the survey as including 25 statements with a Likert scale, and use factor analysis to separate students into inductive- or deductive-learner style. Carlson (1991) refers the reader to a working paper, Carlson and Falk (1986), for further explanation of the learner survey.

TABLE 3
Recent Nonaccounting Educational Technology Studies by Technology Type

Computer-Based Learning (CBL)				Other Technologies				
Computer-Assisted Instruction (CAI)	**Computer-Assisted Teaching (CAT)**	**Computers for Research (CFR)**	**Computers for Computing and Processing (CCP)**	**Audio**	**Still Pictures**	**TV and Film**	**Distance Learning**	**Hypermedia**
• Schwartz et al. (1999) *intelligent tutorial* • Orey and Nelson (1993) *intelligent tutorial* • Clariana et al. (1991) *drill-and-practice*	• Ragan et al. (1993) *multimedia*	• Neuman (1993) *databases*	Not available[a]	Not reviewed[b]	Not reviewed[b]	• Cennamo et al. (1991) *video-based learning*	• Webster and Hackley (1997) • Jayasinghe et al. (1997) • Oliver and Reeves (1996) • Telg (1996) • Martin and Bramble (1996) • Whetzel et al. (1996) • Thach and Murphy (1995)	• Nicaise and Crane (1999) • Gilliver et al. (1998) • Barab et al. (1997) • Hill and Hannafin (1997) *WWW* • Leader and Klein (1996) • Recker (1994) • Shin et al. (1994) • Park and Hannafin (1993) *interactive media* • Jonassen (1991) • Kinzie and Berdel (1990) • Carlson (1991) *interactive multimedia*

[a] "Not available" refers to ET for which no studies were uncovered using our search criteria.
[b] "Not reviewed" refers to ET that is either obsolete or not relevant to accounting and therefore not included in this paper.

available to the system. A software shell, termed STAR.Legacy, was designed to assist students in learning from case-based, problem-based, and project-based learning. Schwartz et al. (1999) report that the software helped students to apply what they had learned in one setting to a new setting (i.e., creating vital linkages among cognitive schemas). Similarly, Orey and Nelson (1993) describe how to theoretically integrate cognitive theory into an ITS. The authors advocate consideration of learner characteristics in the design of an ITS, including the level of the learner's prior knowledge. While neither study is empirical in nature, both Schwartz et al. (1999) and Orey and Nelson (1993) nonetheless provide valuable insight into the integration of intelligent tutorials into the classroom.

An empirical research effort is found in Clariana et al. (1991), who perform an intra-medium study on the effects of different feedback strategies for a drill-and-practice exercise using computerized multiple-choice questions. Their study compares the effects on learning of three feedback strategies: (1) knowledge of correct answer, (2) answer until correct, and (3) delayed feedback. Immediately after completing the drill-and-practice exercise, students completed a post-test based on the material in the exercise. The post-test was re-administered (unannounced) two weeks later to assess student retention. Analysis of variance (ANOVA) revealed a statistically significant main effect for feedback, as well as significant two-way and three-way interaction effects for the within-subjects factors of question level, feedback, and support (text passage provided vs. no text passage provided). Of particular interest is the statistical significance of the interactions. As Clariana et al. (1991) note, if only one level of question had been built into the experimental design, the results would have been directly related to the level of question. Thus, their study highlights the dynamic interplay among learner attributes, media attributes, and task difficulty.

Computer-Assisted Teaching Studies

CAT is largely concerned with multiple-channel communication presentation of instructional materials, including hypertext, hypermedia, multimedia, and the World Wide Web (WWW). *Hypertext* refers to random access to text. *Hypermedia* refers to the nonlinear, random access to information stored in a variety of audio and visual formats, including graphics, sound, animation, and other forms of information transfer (Marchionini 1988). *Multimedia* is the linear representation of information using multiple media, including sound, animation, and other audio and visual formats. Interactive multimedia allows user interaction with the multimedia material, but the interaction does not alter the linear direction of the presentation (Thompson et al. 1992). The *World Wide Web* exemplifies a hypermedia information system that makes information instantly and directly available.

Multiple-channel communication research is grounded in several information processing and cognitive theories, including dual-coding theory (Paivio 1971, 1986), cue summation theory (Severin 1967a, 1967b), and stimulus generalization theory (Severin 1967a). The dual-coding model states that there are two types of information (verbal and imaginal) that are encoded in separate independent, yet interconnected, subsystems (Moore et al. 1996). Stimulation of multiple senses is believed to increase activation of long-term memory, which triggers learning. Cue summation theory

posits a direct relationship between learning and the number of relevant available cues or stimuli. Cue summation theory places special emphasis on pictorial representations (Moore et al. 1996). Stimulus generalization theory contends that learning improves as testing more closely reflects the presentation (Moore et al. 1996). That is, congruency between presented and tested materials stimulates the appropriate cognitive schemas containing relevant information.

Multiple-channel research has resulted in contradictory findings, with some studies reporting that multiple-channel presentation is more effective, and other studies indicating that single-channel presentation is more effective. For example, Hartman (1961) identifies four types of multiple-channel cues: (1) redundant, (2) related, (3) unrelated, and (4) contradictory. Moore et al. (1996, 858) state, "If multiple-channel messages are unrelated or contradictory, they compete with each other, and information interference is the result." Hence, the problem may not be with the multiple channels; rather, irrelevant or incongruent multiple messages may be at the root of the problem. Dwyer (1978) attributes much of the confusion in multiple-channel research to weakness in experimental design, lack of formal hypotheses, and unrealistic research situations. Severin (1967a) maintains that educators may not consider interference between channels. Hsia (1968) holds that inconsistent findings may be due to the failure to consider the capacity limit theorem (the ability to process a limited amount of information at one time) and redundancy of information, causing information processing efficiency to fluctuate (Moore et al. 1996).

Ragan et al. (1993) provide a summary of seven major reviews (139 total studies) of multimedia multiple-channel research. Moore et al. (1996, 867) list the major findings of Ragan et al. (1993) as follows:

1. Multimedia is at least as effective as conventional forms and has substantial cost benefits and efficiency.
2. Frequently, multimedia instruction is more effective than conventional instruction.
3. Multimedia is more efficient in terms of learning time than is conventional instruction (30% savings).

Additionally, Ragan et al. (1993) suggest that media attributes (e.g., a high level of interactivity and level of learner control) contribute positively to the effectiveness of multimedia presentation.

Computers for Research Studies

Neuman (1993) reports the results of a naturalistic study of online and CD-ROM databases to identify which presentation factors enhance and promote higher-level learning. Ninety-two high school students were observed over a semester using 18 online databases and seven CD-ROM databases to complete an assignment. Periodically the students were interviewed and encouraged to provide feedback on the use of the technology to complete their assignment. One of the major findings from this study was that most students felt that they did not have sufficient prior knowledge to complete the assignment. As one student stated, "How could we understand what was happening now if we really didn't understand what the topic was about?" (Neuman 1993, 36). This finding highlights the need for instructional media to consider the level of the student's prior knowledge, either postponing the use of such technology until the student has mastered the requisite background knowledge, or incorporating levels of difficulty into the

media itself so that the student can develop the appropriate cognitive schema commensurate with the new material.

Distance-Learning Studies

Distance learning, which encompasses two-way interactive television, satellite television, video-conferencing, and asynchronous and synchronous web-based instructional delivery, has generated great interest in the academic community. Indeed, several journals, including the *American Journal for Distance Education*, *Journal of Distance Education*, and *Research in Distance Education*, are dedicated exclusively to research in this area. Of the seven studies located in *Educational Technology Research and Design* related to distance learning, six are empirical and one is theoretical. Two of the six empirical studies are evaluative in nature, while four are intra-media studies.

Evaluative studies include Whetzel et al. (1996) and Martin and Bramble (1996). Whetzel et al. (1996) report on efforts to determine the effectiveness of satellite training. In their study, eight satellite and two conventional classrooms were set up for training U.S. Postal Service employees on specific job procedures. The subject pool included 1,177 individuals who voluntarily participated in the training and who took a pre-test and post-test. Based on the results of the post-test scores, which were adjusted for the pre-test scores, the authors conclude that satellite training is useful as a learning medium. Martin and Bramble (1996) describe the teaching of five military courses via interactive video and determine this instructional method to be useful in delivering instruction. Their results show that all students who participated in the satellite training courses passed post-course evaluation exams, with over 90 percent passing on the first attempt.

One area of interest is the skill and knowledge required of distance-education professionals. Telg (1996) and Thach and Murphy (1995) both investigate and identify competencies required of distance-education professionals. Thach and Murphy (1995) conducted a two-round Delphi process wherein 100 distance educators completed a survey identifying distance-education roles, outputs, and competencies. Telg (1996) interviewed 12 full-time television production specialists in distance education to determine what particular competencies they needed to perform their jobs. In both studies, the authors described essentially the same ten competencies: (1) interpersonal communication skills; (2) planning skills; (3) collaboration/teamwork skills; (4) English proficiency; (5) writing skills; (6) organizational skills; (7) feedback skills; (8) knowledge of the distance-education field; (9) basic technology knowledge; and (10) technology-access knowledge.

Jayasinghe et al. (1997) examined the effects of camera angle and monitor placement in a simulated distance-learning environment on several instructor variables. Their results indicated that eye-level cameras and multiple monitors within small groups have a positive influence on instructor credibility, immediacy, and interactions.

Webster and Hackley (1997) investigated teaching effectiveness in distance learning. They examined four categories of influences on distance-learning outcomes, including technology, instructor, course, and student characteristics. They found statistically significant results in all four categories, with the most significant variables being the perceived richness of the medium (i.e., amount of visual and

audio cues), the instructor's teaching style (interactive or noninteractive), and the students' comfort with seeing their image on camera.

In reviewing distance-education studies, we noted a lack of research encompassing newer technologies such as asynchronous and synchronous (also known as "interactive chat") web-based delivery. This void is likely due to the relative newness of this form of distance education, coupled with the relatively long lead times for research publication. More research on the effectiveness and efficiency of these delivery methods is needed.

Television Studies

Over the last 40 years there have been countless evaluation and media-comparison studies on the use of television in the learning process, with the general consensus being that students can learn effectively if television is the delivery vehicle for instructional content. Recent studies attempt to identify the conditions under which television best works as an instructional vehicle. One such example is Cennamo et al. (1991), an ATI study that examines the relationship between mental effort and instruction delivered via three media: interactive video, instructional television, and television. Based largely on the research of Salomon (1984), the authors hypothesize that perception of a given medium as more difficult from which to learn will lead to greater invested mental effort, which will lead in turn to greater learning.

This theory was tested on 71 undergraduate students. The authors find, contrary to other studies, that television is perceived as the most difficult medium from which to learn, while interactive video is perceived as the easiest. The authors find no statistically significant difference in perceived mental effort expended. Post-test exam scores were lower for television (perceived to be the most difficult from which to learn) and highest for interactive video (perceived to be the easiest from which to learn). This finding is opposite to several other studies, notably Salomon (1983, 1984) and Salomon and Leigh (1984). Cennamo et al. (1991) speculate that this result might be attributable to the fact that younger (elementary school) children were used in prior studies, while their study used college students.

Hypermedia Studies

Research in hypermedia is fairly new, and has followed the typical evolutionary patterns demonstrated in other media research. Of the seven empirical papers identified, one is evaluative, one is an intra-medium study, three are ATI studies, one is a combination intra-medium and ATI study, and one is a naturalistic study.

Gilliver et al. (1998) evaluated the usefulness of hypermedia as an instructional delivery tool. These researchers found that an experimental group of students with Internet access to detailed lecture notes and examples, tutorials, and other instructional support materials performed better on the final exam than a control group that did not have access to the material. Gilliver et al. (1998) attributed this pedagogic outcome largely to increased motivation on the students' part due to their active involvement in the learning process.

Much of the research in hypermedia has centered on issues of cognition, learner control, and learner style. For example, through their research on cognitive and information search strategies, Hill and Hannafin (1997) provide insight into strategies used by adult learners to search the WWW. Of

particular interest, these researchers found that the learner's level of meta-cognition (i.e., knowledge of one's own search strategy) affects the learner's search behavior. Specifically, higher levels of meta-cognition were associated with more effective and efficient search strategies. Additionally, they found that participants with high meta-cognition did not appear as prone to disorientation as those did with low meta-cognition.

In a similar study, Barab et al. (1997) explore the profiles of hypermedia users. Students used a hypermedia system to perform two information retrieval tasks. The search path the students navigated was captured in an electronic log file, and cluster analysis was used to generate individual performance profiles. Using the individual profiles, the authors identify four types of navigational performance: (1) model users, (2) disenchanted volunteers, (3) feature explorers, and (4) cyber-cartographers. Barab et al.'s (1997) research sheds light on issues of learner control and has implications for instructional design of hypermedia tasks. Additionally, insight is gained into choices individuals make in navigating open-ended, non-directive media.

Shin et al. (1994) and Leader and Klein (1996) offer empirical ATI studies focusing on the interaction of learner and media attributes. Leader and Klein (1996) investigated the effects of search tool and learner cognitive styles on performance during hypermedia database searches. Their research reveals a statistically significant interaction between search tool and learner cognitive style, and as such has implications for the design of hypermedia and its use in the classroom. Shin et al. (1994) investigated the interaction between learner control, advisement, and prior knowledge on learning in a hypertext environment. The authors found that learners with low prior knowledge retrieve information more quickly and with less frustration when using a program that allows for a relatively low level of learner control. Conversely, learners with high prior knowledge perform better when using a program that allows for a relatively high level of learner control. The Shin et al. (1994) study, in particular, sheds light for educators on instructional design by alerting them to conditions under which limited vs. unlimited access in a hypertext environment might be appropriate.

Nicaise and Crane (1999) is a naturalistic research effort wherein 12 graduate students learned about hypermedia through designing and constructing a chapter for a WWW-based book. The authors embrace a constructivist view of learning in which learning is viewed as an active process that encourages students to discover through hands-on application or to learn through teacher-guided inquiry (Fosnot 1989; Perkins 1992). Nicaise and Crane (1999, 30) state, "Constructionists believe that learning is a process of becoming physically engaged with materials—to manipulate objects and build physical artifacts (representations) of understanding." The authors report that most students were highly satisfied with the course.

Based on this body of education and psychology research, what can accounting educators learn from the studies outside accounting, and what are the issues accounting education researchers should consider in designing ET studies? The next section explores these issues and presents implications of ET research for the domain of accounting.

IMPLICATIONS FOR ACCOUNTING EDUCATION AND RESEARCH

Guidance for Accounting Educators

Many times educators rely on *either* behavioral *or* cognitive theory in designing and delivering instruction. But the studies outside accounting clearly show that the most effective approach for delivering instruction is to consider *both* behavioral and cognitive influences. Based on the review of research outside accounting and a synthesis of behavioral and cognitive theory, we offer the following guidelines for accounting educators to consider in using technology to deliver instruction.

Guideline #1: For learning to be most effective, students should be both cognitively and physically engaged in the task. Computer-Based Learning (CBL) and distance learning are ET methods that require significant interaction between the user and the medium. As such, they represent good tools for actively engaging the learner. A method such as one-way instructional television can be made more interactive by periodically turning off the television or pausing the video and engaging the learners in a discussion of the previously viewed material. Similarly, a multimedia presentation can be more effective if the instructor solicits input and discussion from students during the presentation. Students who are asked to research a tax question will benefit from the discovery process afforded by hypermedia through a WWW search because they must be cognitively engaged in the process of traversing the Web.

Guideline #2: Students should know a priori *what the objectives of the assignment are, and they should be able to determine* ex post *whether they met those objectives.* For example, if an instructor is using a video of an audit in class, the instructor should state clearly *before showing the video* why he/she chose to show this video and what he/she wants the student to get from the video, e.g., "I want you to see how an audit is planned." In other words, using ET in the classroom should be purposeful. By knowing the objectives at the outset, learners can assess their own learning better and can be more strongly motivated to participate actively.

Guideline #3: Feedback should be given to students to monitor their progress and reinforce positive behavior. Feedback type and timing are issues for instructors to consider when using CBL. Most CBL, such as drill-and-practice and intelligent tutorials, recognize the importance of feedback and incorporate automatically some type of feedback into the program. In exercises such as a Monte Carlo simulation, feedback should be interdispersed through the exercise in order to direct the learner's efforts and provide an opportunity for the learner to take corrective action when needed.

Guideline #4: Individual characteristics of the learner should be taken into account in instructional design, e.g., the prior knowledge of the student; the student's level of motivation and, relatedly, mental effort; and the learning style of the student. For example, as discussed above, research has shown that students with prior subject-matter knowledge can perform relatively well on an open-ended hypermedia search. However, students with low prior knowledge generally do not do well on open-ended hypermedia searches, but rather need a limited search space to be effective in their search efforts. Instructors can use this knowledge to more effectively deliver instruction in the classroom.

The level of the class is also related to prior knowledge. For example, sophomores studying principles of accounting have low prior knowledge of accounting. ET use at this level should not be so sophisticated that students are detracted from learning the subject matter.

Following prior knowledge, the next issue is how to motivate students to use technology in the classroom. As previously discussed, motivation comprises three subcomponents: choice, mental effort, and persistence. Most of the time, *choice* is a nonissue, as instructors do not give students the choice whether to use a given technology to complete an assignment. *Mental effort* is related to the reward structure offered. Students generally rise to the challenge when their grade is at stake. To encourage mental effort, instructors should allocate a significant part of their grade to the successful use of the technology. *Persistence* is fostered by integrating the technology throughout the course, thus requiring students to use the technology frequently.

Finally, to the extent student learning styles can be identified and accommodated in the classroom, instructors should seek to match technology with the appropriate learning style. Practically speaking, in large classes, this may be difficult to accomplish. Further, as previously discussed, more research is needed to identify which technologies are congruent with which learning styles.

Guideline #5: Tasks using ET should be organized from simple to complex. Students can learn effectively when they build on small successes and progress from the known to the unknown, the concrete to the abstract. This type of learning has been termed "cascaded problem solving" (Holcomb and Michaelsen 1996). For example, drill-and-practice questions are more effective when they start with easy questions and move to more complicated questions. This instructional approach also tends to build student confidence. Further, by progressing from the simple to the complex, students are able to connect previously learned information to new information.

Guideline #6: Where possible, learners should progress through the lesson at their own pace. Self-paced instruction is not possible in CAT, since the instructor usually has a fixed time frame during which to deliver a block of instruction. However, self-paced instruction often is possible when using CAI, such as drill-and-practice exercises and hypermedia searches, to provide for self-paced instruction. Some students will need to go back several times to review material, while others will be able to progress more quickly. Allowing the learner to regulate his/her pace through a lesson recognizes that individuals are unique in how they process information.

Guideline #7: The instructor should attempt to match higher-order learning objectives with ET that is more conducive to higher-order thinking, and lower-order learning objectives with ET that is more conducive to lower-order thinking. Most CAI applications are drill-and-practice- and tutorial-oriented. These technologies do a good job of delivering and reinforcing procedural knowledge (associated with lower-order thinking skills), such as technical accounting rules (Boyce 1999). Undoubtedly, students can benefit from repetition and drill on often-complex accounting rules. However, the accounting profession as a whole has begun to recognize the importance of deep learning as opposed to surface learning, and critical thinking as opposed to rote memorization of rules and facts

(Accounting Education Change Commission 1990). ET, such as simulations and hypermedia, can foster high-order thinking skills such as logical and deductive thinking, analytical reasoning, judgment and decision making, and problem solving. CCP tools such as spreadsheets (which by themselves would be considered low-order tools) can be used to promote high-order thinking skills by requiring students to make decisions and/or recommendations based on spreadsheet results—in effect, to do more than simply create the spreadsheet.

The above guidelines provide specific directions to accounting educators. There are, however, two other important issues that accounting educators must undoubtedly face: (1) how to become competent themselves in the use of technology in the classroom; and (2) how to determine which technology is appropriate for a given class or assignment. With respect to competency, we should note that in today's dynamic technological environment, not many instructors believe they attain the goal of complete competency. By the time one begins to approach a comfort level, the technology changes—new versions come out, new operating systems are proffered, and new tools are continually offered. Instructors must face the fact that competency is a continual goal. They must commit to a continual process of professional development. Some help with professional development is usually available at the university in the form of computer classes. Instructors should take advantage of such classes, as we have found this format to be an efficient and effective method of learning a new technology. Inexpensive tutorials are available as well. The key here is to commit to a constant improvement process.

The second issue is how to choose technology appropriate to a class or assignment. Guidance on this subject is available in the International Federation of Accountants (IFAC) International Education Guideline No. 11, *Information Technology in the Accounting Curriculum* (IFAC 1995). The AICPA publishes IFAC Guideline No.11 along with an AICPA task force interpretation of the guideline called *Information Technology Competencies in the Accounting Profession: AICPA Implementation Strategies for IFAC International Education Guideline No. 11* (AICPA 1996). This information details strategies for implementing a study of technology within the accounting curriculum, as well as specific skills and competencies needed by accountants. Educators will find this guideline and interpretation to be useful references for determining which skills and competencies are most important, as well as which technology applications are appropriate for which subject.

The guidelines offered above are directed primarily at accounting educators. What issues should accounting researchers consider in designing ET research studies? Is there a way to put this body of knowledge together into a framework for accounting research? The next section answers these questions and provides some direction for ET research.

Guidance for Accounting Education Researchers

To provide guidance to accounting education researchers, we must first update accounting ET research. Rebele et al. (1998) provide a review of ET studies published in the accounting education literature during the period 1991–1997. Table 4 updates their literature review through midyear 1999. The studies listed in Table 4 were compiled from a review of recent research

TABLE 4
Educational Technologies by Type

Computer-Based Learning (CBL)				Other Technologies		
Computer-Assisted Instruction (CAI)	**Computer-Assisted Teaching (CAT)**	**Computers for Research (CFR)**	**Computers for Computing and Processing (CCP)**	**Audio**	**Still Pictures**	**TV and Film**
• Gujarathi and McQuade (1998) *electronic tutorial* • Parker and Cunningham (1998) *electronic tutorial* • Fogarty and Goldwater (1996) *Monte Carlo simulations* • Horsfield (1995) *simulation*	• Boyce (1999) • Butler and • Mautz (1996) *multimedia*	• Yancey and Klemm (1996) *CD-ROM tax research*	• Fogarty and Goldwater (1996) *uses Excel to perform Monte Carlo simulations*	Not reviewed[a]	Not reviewed[a]	• Evans (1998) *videos* • Siegel et al. (1997) *videotapes of audits* • Fordham (1996) *videos* • Martin et al. (1995) *videos* • Greenspan and Strawser (1995) *video* • McInnes et al. (1995) *videotaped lectures*
					Distance Learning[b]	**Hypermedia**
					• Seay and Milkman (1994) *ITV*	• Sangster and Mulligan (1997) *WWW*

[a] "Not reviewed" refers to ET that is either obsolete or not relevant to accounting and therefore not included in this paper.
[b] ITV = interactive television

published in *Issues in Accounting Education*, the *Journal of Accounting Education*, *Accounting Perspectives*, *Accounting Education: A Journal of Theory, Practice, and Research* (renamed in 1998 to *Advances in Accounting Education*), *The Accounting Educators' Journal*, and *Accounting Education*.[4]

Tables 3 and 4 show some interesting trends. It is readily apparent that ET research has progressed away from one-way television toward the newer technologies of distance learning and hypermedia (which encompass interactive multimedia). Of the 24 education studies reviewed, seven are distance-learning studies and 11 are hypermedia studies (or some variant). On the other hand, accounting research is still very much involved in television issues, particularly the use of videos to supplant or supersede lectures. Accounting researchers are just beginning to examine the newer technologies of distance learning and hypermedia. More research is needed in these areas.

Another interesting comparison is with respect to the types of studies being performed in education research vis-à-vis the types of studies being performed in accounting. Educational researchers are performing more empirical work, and their studies have progressed away from evaluation studies and media-comparison studies toward intra-medium, ATI, and naturalistic research. Table 5 reveals that of the 15 recent accounting technology studies published, less than half (six) are empirical, while nine are primarily descriptive in nature. Additionally, Table 5 shows that of the six empirical studies, four are media-comparison studies (primarily comparing a given technology-delivery method to traditional classroom instruction to see which is "better" for learning); one is an evaluation study (examining the usefulness of using a given technology); and one is a combination evaluation, media-comparison, and ATI study (examining the usefulness of multimedia, comparing multimedia presentation to traditional classroom presentation, and then examining whether learner style interacts with the medium). The descriptive studies by their nature cannot be classified as a particular type of study. The accounting ET studies have been dispersed over several areas, with no one dominant area of accounting. Accounting can benefit from more empirical research, particularly intra-medium, ATI, and naturalistic, or qualitative research.

Several researchers have attempted to develop technology classification schemes based on individual medium characteristics, including projected-vs.-nonprojected media, motion-vs.-still media, and text-vs.-graphic media (Thompson et al. 1992). However, a classification scheme that focuses only on media attributes ignores the interplay between the media and the learner, as well as individual attributes and environmental factors. Given the paradigm of dual behavioral and cognitive theory influences, we propose in Figure 1 a framework that considers all these key components as a guide for accounting education researchers.

Figure 1 provides a framework that classifies media attributes according to transmission mode (synchronous or asynchronous) and learner control

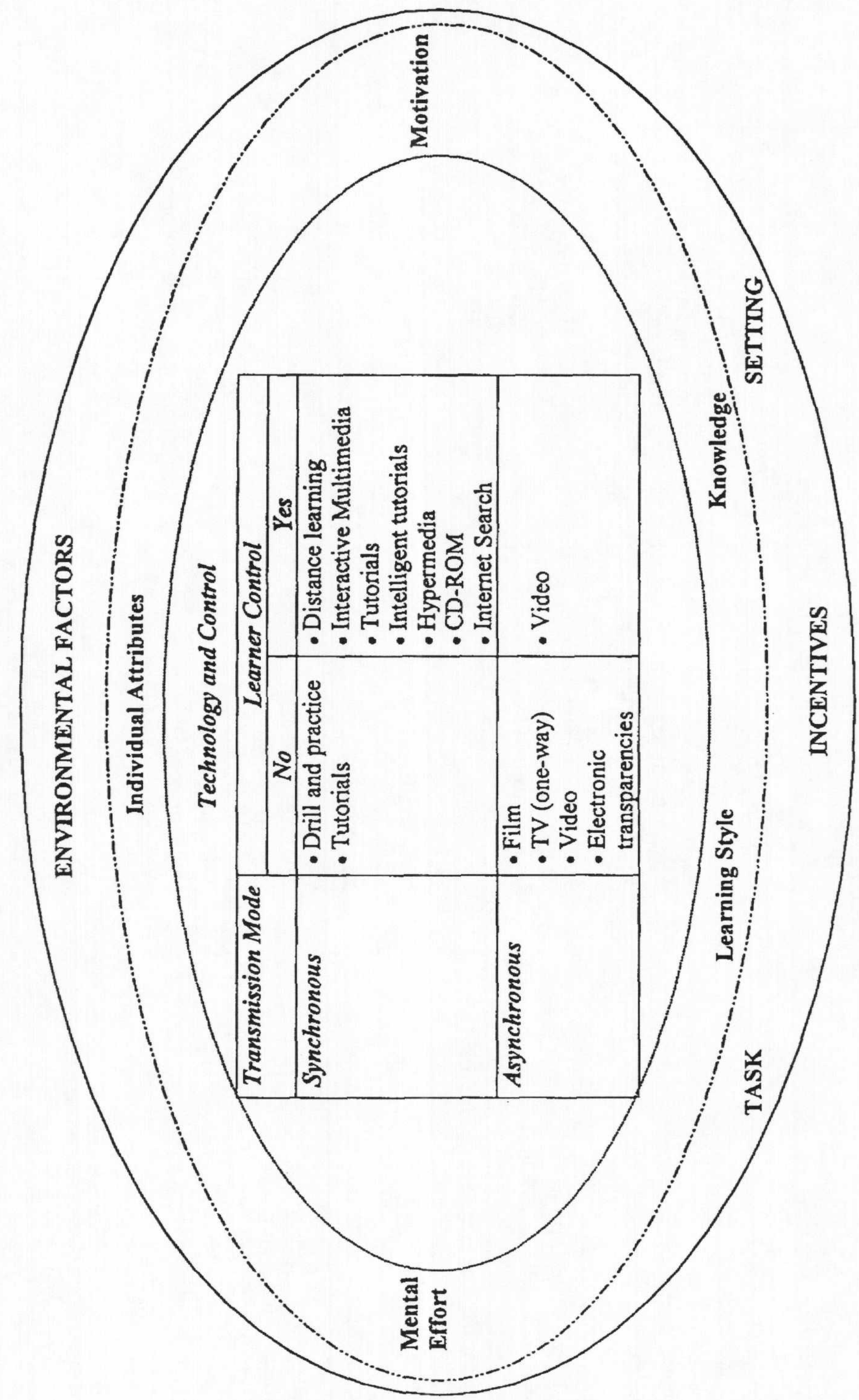
[4] Cutoff issues of accounting journals reviewed in this paper are as follows: *Issues in Accounting Education* (Vol. 14, No. 2); the *Journal of Accounting Education* (Spring/Summer 1999); *Accounting Education* (Vol. 8, No. 1, 1999); *Accounting Perspectives* (Fall 1996); *Accounting Education: A Journal of Theory, Practice, and Research* (Vol. 2, No. 2, 1997); *Advances in Accounting Education* (Vol. 1, 1998); and *The Accounting Educators' Journal* (Spring 1998).

TABLE 5
Accounting Studies by Type and Area

Study (by Year)	Type of Study	Area
Panel A: Empirical Studies[a]		
Evans (1998)	Evaluation	Cost and management accounting
Siegel et al. (1997)	Media-comparison	Auditing
Butler and Mautz (1996)	Evaluation, media-comparison and ATI	Information Systems
Fordham (1996)	Media-comparison	Information Systems
McInnes et al. (1995)	Media-comparison	Management accounting
Seay and Milkman (1994)	Media-comparison	Cost accounting
Panel B: Descriptive Studies[b]		
Boyce (1999)	Not Applicable[c]	General
Gujarathi and McQuade (1998)	Not Applicable[c]	Financial
Parker and Cunningham (1998)	Not Applicable[c]	Tax
Sangster and Mulligan (1997)	Not Applicable[c]	Information Systems
Fogarty and Goldwater (1996)	Not Applicable[c]	Tax
Yancey and Klemm (1996)	Not Applicable[c]	Tax
Greenspan and Strawser (1995)	Not Applicable[c]	General
Horsfield (1995)	Not Applicable[c]	Auditing
Martin et al. (1995)	Not Applicable[c]	Management accounting

[a] "Empirical studies" are based on statistical analysis of quantitative data.
[b] "Descriptive studies" are studies that provide theoretical insight but not analysis of data.
[c] "Not applicable" refers to descriptive studies for which the type of study does not apply.

FIGURE 1
Framework for Technology-Based Accounting Education Research



(presence or absence). Some technologies, such as video, appear in multiple categories, because the presence or absence of learner control may vary within type of medium. For example, an instructional video shown in class may not give the student any control over the process, while an instructional video that may be checked out from a video library and viewed multiple times provides some level of learner control to the student.[5]

In addition to media attributes, Figure 1 reflects individual attributes, including the learner's prior knowledge of the subject matter, the mental effort exhibited by the learner, the learning style of the learner, and the learner's motivation. Additionally, the framework considers the influence of environmental factors on learning, such as the specific task, extrinsic incentives, and the learning setting. While there are likely many more individual and environmental attributes that are interrelated with ET, those listed in Figure 1 are intended to reflect a representative selection of such factors. It is the study of the interactions among technology, control, individual attributes, and environmental factors that will yield the most interesting and fruitful results for accounting educators.

One learner attribute that merits attention in particular is learning style. Little research exists on congruence of learning style with ET. For example, which learning styles are more suited for hypermedia search? Which are congruent with an interactive-chat format for a graduate accounting distance-learning class? These types of questions are ripe for accounting researchers. Three accounting studies that do consider student-learning styles are Siegel et al. (1997), Evans (1998), and Butler and Mautz (1996). Siegel et al. (1997) consider a student's individual learning style in an experiment involving the effectiveness of watching a video on audit. Similarly, in developing a series of videos to teach introductory cost and management accounting, Evans (1998) employed a holistic approach, incorporating material prepared for both visual and verbal learners. Butler and Mautz (1996) examined the interaction of learner style with presentation mode (traditional, text-based, black-and-white visual aids vs. multimedia presentation). These studies are strengthened by consideration of learner characteristics. More research of this type is needed to understand the interaction between the student's learning style and the medium.

Another issue of importance is the assessment of student learning using a given medium. Most assessment has occurred by comparison of a score on a final examination between a control (without use of the medium) and experimental (with use of the medium) group. Learning enhancement is widely believed to occur if the score for the experimental group is significantly higher than the control group's. While a final exam score is unarguably one measure of learning, it is not the only—or even best—measure. Other forms of assessment need to be developed and explored, as well as other assessment measures, such as satisfaction, attitudes, and cost effectiveness.

As previously noted, more research on the newer web-based distance-education technologies is needed.

[5] Fordham (1996) discusses using out-of-class videos for remedial instruction. Under this design, students were allowed to check out videos and view them at their discretion. Fordham (1996) notes that the most compelling advantage of using videotape is the potential for selective viewing, i.e., students could skip material about which they were already knowledgeable, and spend more time on topics in which they needed remediation.

According to a recent survey of distance education in higher education institutions, 57 percent of distance-education courses in higher education were delivered by two-way interactive videoconferencing. Interactive chat was offered by 14 percent of institutions, while 22 percent offered asynchronous Internet-based delivery (Lewis et al. 1997). Although synchronous videoconferencing is still the dominant delivery method for distance education, the survey notes that the trend is toward more institutions offering web-based delivery. Issues such as the individual attributes necessary for successful use of these distance-education delivery techniques have not been addressed and may provide a fruitful area for researchers.

Finally, care needs to be demonstrated in the experimental design of ET research. Many early ET studies were plagued by problems of low power, low sample size, lack of control groups, maturation, and similar design issues. While randomization of subjects may not always be possible, a quasi-experimental design can still be employed to ensure the highest internal validity possible under the circumstances. For higher internal validity, the ideal design is a laboratory experiment such as that conducted by Butler and Mautz (1996). In controlling for as many extraneous variables as possible, this experimental design strengthens the link between the treatment and the outcome.

CONCLUSION

This paper synthesizes a wide spectrum of education literature dealing with the use of technology in the delivery of instruction. The timeliness, relevance, and importance of this subject matter is readily apparent, as technology is shaking the foundation of the "brick and mortar" approach to college-level education. Rapidly expanding technological advances are driving a new instructional paradigm—the transition from physical to virtual learning environments. If educators are to keep the institutional walls of higher education from crumbling down altogether, it is imperative that they learn to harness the enormous power and potential of instructional technology. In this light, the review and analysis of technology-related education literature presented in this paper may provide guidance to accounting educators and education researchers.

Accounting educators can use the framework depicted in Figure 1 as a starting point for thinking about the type of instructional technology that is most likely to succeed within a given context. As illustrated, environmental, individual, and technological factors are critical components in making this determination. For example, if the setting is a traditional classroom and the task is to teach rule-based accounting procedures (environmental factors), and if the students' accounting knowledge is sufficient to handle the nature of such procedures and their motivation to learn is high (individual attributes), then electronic transparencies may be appropriate. The instructor might also supplement the students' learning with intelligent tutorials.

In another circumstance, assume that the setting is a computerized classroom and the task is to teach critical-thinking skills by having small groups of students solve a case. If students are psychologically engaged in the task (i.e., expending considerable mental effort) and are properly motivated, a combination of Internet search and hypermedia applications may be an effective solution. While the combinations of environmental, individual, and technology considerations are too numerous

to elaborate in this article, accounting educators can use Figure 1 as a guide when choosing among several instructional technologies.

Accounting education researchers can also learn a great deal from the review and analysis of educational studies presented in this paper. For example, empirical research dealing with synchronous technology where learner control is present (see Figure 1) would be valuable to accounting educators. Researchers should strive to blend into their studies process-oriented learning theories from cognitive psychology and outcome-oriented theories from behavioral psychology. Experimental designs, in laboratory and classroom settings, would be most useful in identifying "cause-and-effect" relationships among environmental, individual, and technology factors. Presently, there are more research questions than answers regarding the effective use of instructional technology in accounting—a situation that should be applauded by accounting education researchers.

For those searching for accounting resources in ET, Holcomb and Michaelsen (1996) discuss the Center for Educational Technology in Accounting (CETA) located at the University of North Texas. The purpose of the Center is to provide support to accounting faculty engaged in ET education and research issues. Another source for accounting-related ET resources is Professor Robert Jensen's Internet site, at http://www.trinity.edu/~rjensen/homepage.htm. Professor Jensen offers a current commentary on hardware and software trends, as well as links to numerous technology resources.

It is important to remember that accounting educators and researchers should not jump on the latest technology bandwagon simply because it is rolling nearby. The search for excellence in accounting education should begin with the ultimate objective of maximizing student learning. In some instances, "chalk and blackboard" may be the best instructional solution. However, accounting educators should continually scan the technology horizon and incorporate solutions that are most likely to maximize the ultimate educational objective.

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