RECOMMENDATIONS FOR PRE-SERVICE ELEMENTARY TEACHERS REGARDING THE IMPLEMENTATION OF INFORMATION TECHNOLOGY IN THE CLASSROOM

By

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International comparative studies demonstrate there is a substantial need to improve student achievement in the United States. One possible solution for improving student achievement is to integrate information technology into the classroom. This thesis synthesizes the research on four components of students' uses of information technology in the classroom including general purpose, generic tools, information sources, hypermedia/multimedia and computer assisted instruction.

An ERIC search was conducted to find possible studies to include in the synthesis. The most current studies were then selected from the results of the search. When possible, meta-analyses were also selected to be included.

The research demonstrates that the use of information technology in the classroom has a positive effect on student achievement. However, there are possible barriers to the widespread implementation of information technology in the classroom. Several of the possible barriers are also discussed in the thesis.

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INTRODUCTION

Information technology is an extremely valuable teaching tool in the modern world. "Information technology (IT) can be thought of as a mind tool - an aid to solving complex problems and accomplishing complex tasks" ("Information Technology," 1998, p. i). The computer is one of the most recognized tools of IT. In an effort to convince pre-service elementary teachers to implement IT in the classroom to improve student learning, this paper presents a synthesis of the research on using IT for educational purposes. Based on this synthesis of information, the paper also contains many recommendations for its implementation. Although the research demonstrates that the use of information technology in the classroom would increase student achievement, there are numerous barriers that might prevent pre-service teachers from using it in their classroom. Several barriers and possible solutions to overcoming these barriers are also discussed.

International comparative studies administered by the International Association for the Evaluation of Education Achievement (IEA) suggest that there is considerable room for the improvement of student achievement in the United States (Mullis et al, 1997; Matheson et al, 1996; Martin et al, 1997). For example, of 17 countries that participated in a study on student achievement in math, U.S. fourth graders ranked ninth. This rank fell to thirteenth for students in the eighth grade (Mullis et al., 1997). Because of the results of these studies, "the United States is currently devoting considerable

attention to establishing high standards for student achievement" (Matheson et al., 1997, p. 45). It will soon be the job of pre-service elementary and secondary teachers to ensure that all students are meeting these new, higher standards. Pre-service teachers can increase student achievement by implementing information technology in their classroom when they become teachers.

Several different models illustrating teachers' use of IT in education exist. Student productivity, the component that I have chosen as the structure of my thesis, is part of a model that has three main components to teachers' use of technology: Personal productivity, student productivity and professional productivity (See appendix A). Personal productivity is using information technology to do day-to-day tasks better and more efficiently. An example is using a software program to do one's income taxes. Professional productivity is using technology to make the tasks required by a professional teacher easier and more efficient. It includes teachers' uses of the computer such as *gradebook programs*[1], *lesson planning software* and *individual education program (IEP) software.* There are four major components to student productivity: (1) General purpose, which includes word processors, databases and spreadsheets, (2) information sources such as the Internet, databases, references, (3) hypermedia/multimedia, which is a "document that may combine text, sound, graphics, and video into a non-linear, interactive communication that can only be effectively read/viewed by the use of a computer" (Moursund, 1995, p. 70) and (4) computer assisted instruction (CAI) which is "the interaction between a student and a computer system designed to help students learn" (Moursund, 1997, p. 32). This thesis will focus only on student productivity.

[1] Italicized words appear in the glossary.

In the spring of 1998, Sharon Yoder conducted a survey titled "Technology and You, the Teacher" in EDUC 410 Content Area Methods, Reading and Writing, Technology, Diversity (See appendix B). The purpose of the survey was to determine where pre-service teachers felt they were in terms of using information technology in the classroom. The survey was distributed to all 45 students in the class at the beginning of the term. Of the 45 students, 5 students placed themselves at the entry phase or the first of five phases, 22 students placed themselves at the adoption phase or the second phase and 20 students placed themselves at the adaptation phase or the third phase. Currently, pre-service teachers at the University of Oregon who have never received instruction on implementing IT in the classroom felt that they had a lot to learn about doing so. By the end of their pre-service training, I would like pre-service teachers to place themselves at the invention phase of IT which is the highest level on the scale.

THE CONSTRUCTIVIST MODEL

Pre-service teachers must understand the Constructivist model because it provides a viable alternative to current methods of instruction and many educators believe that the implementation of IT in the classroom should be based on Constructivism. The Constructivist model is an approach to teaching and learning rooted in the work of Piaget and Dewey (D. Moursund, personal communication, August 12, 1997). "Constructivists believe that learning occurs through a process in which the student plays an active role in constructing the set of conceptual structures that constitute his or her own knowledge base" ("Report to the President," 1997, p. 33). In other words, the students take a more active role in their learning than they do in a traditional classroom where the teacher lectures and the students read textbooks. The President's Committee (1997) "believes there to be a high likelihood that many or all of the essential elements of this approach could play a major role in improving the quality of our nation's elementary and secondary schools" (p. 35).

There are several "essential elements" in the Constructivist approach. The first is that many of the activities in the classroom are project-based ("Report to the President," 1997). Instead of practicing isolated skills, students incorporate many skills into a project. The second is that the students control their own learning. For example, students may be allowed to choose the topics they wish to study ("Report to the President," 1997). The

third is that students often work in collaborative groups (Viadero, 1997). The fourth is that students "learn to think critically and analytically" and, finally, students often produce products to illustrate their learning (Viadero, 1997, p. 3). The result is an "approach to educational practice that places the locus of initiative and control largely within the student, who typically undertakes substantial, 'authentic' tasks, presented in a realistic context, that requires the self-directed application of various sorts of knowledge and skills for their successful execution" ("Report to the President," 1997, p. 34).

IT is useful in a Constructivist learning environment. Students can work collaboratively at the computers and computers can be used to produce a wide variety of products through which students may demonstrate their learning. The President's Committee (1997) agrees that "it seems likely that the student-centered Constructivist paradigm may ultimately offer the most fertile ground for the application of technology to education" (p. 35).

GENERAL PURPOSE, GENERIC TOOLS

One of the components of IT that may be valuable in a Constructivist learning environment is a general purpose, generic tool. General purpose, generic tools are "Software programs such as word processors, spreadsheets, database managers and graphic packages that cut across many disciplines" ("Information Technology," 1998, p. 7). These tools can be used across almost all areas of classroom curriculums. In this section, current use of general purpose, generic tools is outlined, followed by a review of the research on word processing and an example of using a database in a classroom. Pre-service teachers may use this information to develop curriculums for their classrooms in order to reach their goal of the invention phase.

A survey distributed by IEA found that general purpose, generic tools are widely used in classrooms (Becker, 1992). IEA determined that of computer use by K-12 students in the U.S., 41 percent of the use "involves the acquisition of keyboarding skills, instruction in the use of word processing, database management, spreadsheet, and other software tools" ("Report to the President," 1997 p. 40). Although research demonstrates that the general purpose component is widely used in the schools, pre-service teachers can do much more with the tools to increase students learning when they become teachers.

Instead of using the general purpose tools to help students learn in the basic curriculum areas such as English or Social Studies, most educators are currently using the tools to teach students about computers. It is reported that word processing is taught in

order to instruct students in computer skills ("Report to the President," 1997). Although it is important that students acquire the ability to use a computer, experts agree that it would be more beneficial to incorporate the skill of word processing with other areas of the curriculum such as Writing, English or Social Studies ("Report to the President," 1997). In other words, the computer skills being taught in the schools need to be related to process writing and using the computer as an effective aid to writing.

Viadero (1997) is convinced that generic tools in the classroom improve student learning. She states that "Even simple technology, such as word processors to help in writing instruction, has proved its worth in the classroom" (Viadero, 1997 p.6). Stephen Maurcus, a co-director of the South Coast Writing Project and a researcher at the University of California-Santa Barbara, claims that "Students are more willing to do more editing, to spend more time reviewing their text and improving it" than when they use a pencil and paper to complete a writing assignment (Viadero, 1997, p. 2). He believes that IT aids in the implementation of some of the best theory and practice with respect to the teaching of writing.

Marcus' claim that students edit their text more thoroughly and, therefore, improve the quality of their writing, when using a word processor is logically valid; however, researchers are having a difficult time supporting this specific claim with empirical evidence. In a *meta-analysis*, Bangert-Drowns (1992) examined seven studies that investigated the difference between the frequency of revisions on word-processed writing samples and hand-written writing samples. Four studies concluded that word processing increased the number of revisions while three studies concluded that it did not. Bangert-Drowns (1992) offers a reason why the data are controversial: "the revisions of

students writing their postinstructional compositions on computer may be undercounted because students may make many revisions while crafting an electronic document on computer that disappear on the final paper copy" (p. 85). Nonetheless, the data are inconclusive and further research is required.

Despite the inconclusive data on revisions using a word processor, there is positive empirical evidence that writing quality increases with the use of a word processor. Bangert-Drowns (1992) concluded, "Writing quality is frequently reported to have improved after instruction with word processing" (p. 87). He found that of 28 studies conducted on using word processors in the classroom, 66 percent reported an improvement in the quality of writing (Bangert-Drowns, 1992, p. 87). Robert M. Schramm (1991), an assistant professor in the Department of Business Education and Office Administration at the University of Wisconsin-Whitewater, found similar results in his meta-analysis. He concluded that, in general, "There is a small, but significant improvement in the writing quality of those students using word processing equipment when compared to those students using traditional writing methods" (Schramm, 1991 p. 10).

A more recent study, conducted by Ronald D. Owston and Herbert H. Wideman (1997), also found improvements in students' writing quality when using word processors. In this three year study, which began when the students were in third grade, the researchers compared the writing quality of students who had high access to computers (3 computers for every one student) in their school and who used word processors for writing and students who had little access to computers (15 computers for every 1 student) in their schools and who did not use word processing for writing. Each

student received a message score ("a measure of the meaning and content quality") and a medium score ("a measure of the quality of the form and surface features of the writing") for his or her writings (Owston & Wideman, 1997 p. 213). The average message score and medium score for students who used a word processor for writing were superior to the average message and medium score for students who did not use a word processor for writing.

Bangert-Drowns (1992) and Schramm (1991) also found other encouraging results to support the use of word processors in schools. Based on his meta-analysis, Bangert-Drowns (1992) determined that students who had previously been having difficulty with writing improved more under word processing instruction than typical writing instruction (p. 69). In addition, Schramm (1991) reported that inexperienced writers gained more from the word processing instruction than did experienced writers (p. 10).

The improvement in the quality of student writing as a result of word processing correlates with an improvement in students' attitude toward writing. Research demonstrates that students produce better quality documents after word processing instruction. Schramm (1991) claims that, in general, "There is a large, significant, and positive effect on the attitude of students toward writing when using word processing equipment as compared to students using traditional writing methods" (p. 10).

Other evidence that supports the notion that using word processors in the writing curriculum is advantageous to student's learning is found in a study conducted by Walt Haney, a researcher at Boston College. Haney administered the same writing task to two different groups of middle school students. One group of students wrote the writing task in long hand while the other group wrote the writing task on a word processor. Before the

writing samples were evaluated, the samples that were written in long hand by the students were typed. When judges scored the writing samples based on the same set of grading criteria, the students who had originally word processed the writing sample scored higher. Since most performance assessments are to be handwritten, Haney "wonders whether they are accurately rating students' full capabilities" (Viadero, 1997, p. 3).

Although most of the research states that word processing improves the quality of student writing, one factor that must be taken into account is the efficiency of using a word processor versus handwriting. In a study that compared the writing of students using a pen and students versus using a word processor, researchers found that "the computer diverted a significant amount of time from the task of composing" (Freedman & Clarke, 1989, p. 76). Typographical errors were a persistent interruption to student's composing on a computer (Freedman & Clarke, 1989). Of the eighth graders examined in the study, the percentage of time they spent correcting typing errors varied from 1.2 percent to 12 percent. Therefore, the skill of keyboarding must be a part of the curriculum in classrooms that use word processors.

Both Sormunen (1991) and Nichols (1995) agree with the above statement. "Keyboarding should be taught during the elementary school years" (Nichols, 1995 p. 15). Based on a research study of 121 students in grades 3 through 6, Nichols (1995) recommends a teacher-intensive approach to teach keyboarding rather than an approach that is software driven. She found that the teacher intensive approach was more time efficient and, although the students who completed this program typed an average of 1.6 words per minute less than the students in the software driven program did, the typing

resulted in fewer errors. "Based on the results of this study," Nichols (1995) "finds it reasonable to recommend the teacher intensive approach to keyboarding instruction as an efficient and effective method" (p. 24).

There are many skills that students must learn. Therefore, teachers must make efficient use of classroom time. While writing quality does improve with the use of a word processor, students must learn to type in order to make using a word processor efficient (Schramm, 1991, Bangert-Drowns, 1992, Freedman & Clarke, 1989, Nichols, 1995, Sormunen, 1991). Based on the evidence presented regarding word processing, keyboarding and writing, I recommend that teachers in training learn to develop curriculum that includes a teaching keyboarding skills and using a word processing in their curriculum to improve students' writing quality.

There are many other generic tools in addition to the word processor that pre-service teachers should consider when planning their curriculum. The spreadsheet and the database are two such generic tools. The spreadsheet and the database can be taught as computer skills separate from the existing curriculum, but experts suggest that they be incorporated into the curriculum. The President's Committee (1997) recommends that spreadsheets become an integral part of the math and science curriculum and Peck & Hughes (1997) demonstrate a way in which the database may be incorporated into the existing curriculum. (p. 41)

Sharon Hughes, a first grade teacher participant in the four year partnership project, the Cooperative Alliance for Gifted Education, incorporated a database into her Social Studies curriculum. The topic of Hughes' first grade students' database was famous black people. She and the students collaborated with one another to create the

database. The response of the students to this project yielded several interesting results. Not only did these first grade students learn how to create and use their own database, they began "thinking differently to organize, synthesize, and analyze information; interacting socially; integrating the modes of language and producing for an authentic audience" (Peck & Hughes, 1997, p. 115). So, incorporating a database into the curriculum instead of teaching it as a separate skill increased student learning in more ways than one. The same recommendation can be reached for all general purpose tools: Pre-service teachers should incorporate them into their curriculum when they become teachers, not teach them as a separate skill.

INFORMATION SOURCES

Information sources include the Internet, databases and references. A particularly important information source to education is the *Global Library* found on the World Wide Web. This section contains information on the current number of schools and classrooms connected to the Internet and recommendations for pre-service teachers on integrating information sources into their curriculums. It also contains information on what the research says about using information sources in the classroom such as e-mail and the Global Library.

Currently, most students have access to information sources via the Internet. In 1997, 78 percent of all schools in the United States were connected to the Internet while 27 percent of all classrooms were connected ("Information Technology," 1998), 1998). This is a significant improvement from 1994 when only 35 percent of schools and 3 percent of classrooms were connected ("Information Technology," 1998). This rapid progress in providing schools and classrooms with Internet access is expected to continue. In fact "The National School Boards Association in its July/August 1998 Technology Leadership News, reported that Quality Education Data indicates that 82 percent of schools now have some connectivity to the Internet and this will increase to 96 percent by the end of the 1998-1999 school year" ("Information Technology," 1998, p. 17).

Since it is highly likely that pre-service teachers will have access to information sources in their schools or classrooms, they must determine the best way to integrate them

into their curriculum. Schools and classrooms that already make use of the Internet are reaping the benefits. These schools and classrooms can serve as a model for pre-service teachers. Thirty-six schools in California that participated in the National Geographic Society's Kids Network are a good example. The National Geographic Society's Kids Network is a ten-year-old program that matches each classroom with 9 to 15 other classrooms around the United States. These classrooms collaborate through the Internet and a central computer system at National Geographic Society on "eight-week-long research projects on everything from water quality to recycling" (Viadero, 1997, p. 1).

An independent study conducted to determine the results of using the National Geographic Society's Kids Network in the 36 California schools found positive results. The study concluded that students who participated in the program scored better than other students who did not participate in the program on their understanding of some scientific concepts. They also determined that the students who had participated in the study "outperformed control-group students on questions unrelated to their unit of study, such as tasks that asked test-takers to interpret bar graphs of children's ice cream preferences" (Viadero, 1997, p. 1).

Another way pre-service teachers may utilize the Internet to increase student learning is by setting up an e-mail learning community (Baugh & Baugh, 1997). An e-mail learning community consists of classrooms that exchange information with each other via e-mail (Baugh & Baugh, 1997). These communities benefit students by allowing them to communicate with other students in different cultures. Baugh and Baugh, from Louisville, Kentucky, set up an e-mail learning community with a classroom in Albuquerque, New Mexico. This community allowed students from each classroom to

practice their second language skills. They also learned valuable social studies and multicultural lessons. "Multicultural learning occurred when students' exchanged information about the holidays and special people that their cultures honored each month of the year" (Baugh & Baugh, 1997, p.40).

With all the benefits of an e-mail learning community and the easy accessibility to a learning community, it is strongly recommended that pre-service teachers plan to implement one in their classroom. The ePals Classroom Exchange is one mechanism for doing so. The ePals Classroom Exchange, founded in early 1996, "provides students and teachers with an opportunity to freely meet and correspond with other classrooms from around the world" ("Classroom Exchange," 1998). There are now over 145,000 students and teachers involved in the program from more than 70 countries, speaking over 60 languages ("Classroom Exchange," 1998). What better way, short of physically visiting a different culture, to give students hands-on experience?

The research discussed above concluded that the interactive nature of the Internet is beneficial to student learning. Teachers also claim that the Internet is beneficial to student learning because it "breaks down the four walls of the classroom" by allowing students access to an unlimited amount of information on the World Wide Web (Viadero, 1997, p. 3). Through the World Wide Web, students have access to a Global Library.

There is a general consensus among educators regarding which school libraries allow students to learn the most. For example, the number of items in a collection is used extensively to determine the collection's quality (Doll, 1997). Another measure of quality is how up-to-date the collection is. (Doll, 1997, p. 96). The quality of library collections may also be judged by comparing library holdings with a standard list or bibliography

such as the *Children's Catalog* or the *Elementary School Library Collection* (Doll, 1997). Finally, Moursund states that two other standard arguments are that "multiple sources of information is good" and "original sources are better than the secondary sources in the books" (personal communication, August 17, 1998).

According to the guidelines for determining which school libraries allow students to learn the most, the Global Library is the best library for student learning. The Global Library on the World Wide Web meets and exceeds all aspects of the accepted criteria for a school library. Although research may not need to be conducted to determine that the Global Library is beneficial to student learning, it does need to be conducted to determine how to help students learn to make effective use of this emerging Global Library.

HYPERMEDIA/MULTIMEDIA

Hypermedia or multimedia has two uses in the classroom. Teachers can use hypermedia to present information to students, or students can use hypermedia to demonstrate their learning. "Using hypermedia authoring tools, students can present their work in the form of a computer program that shares the knowledge with an audience" (Moursund, 1995, p. 70). Software programs such as Hyperstudio make this a fairly simple process. This section examines the rationale for using hypermedia in education and what the research, including several meta-analyses, say about using hypermedia in the classroom.

The rationale for the use of hypermedia was developed in the 1940's and has continued to be a prominent theory in education throughout the decades. "The assumption is that hypertext/hypermedia systems, because of their ability to represent subject matter content from different views, in different contexts, and by means of different symbol systems, may contribute to the enhancement of learning" (Tergan, 1997 p. 5). "The use of multiple perspectives and modes of representation in instruction and learning is recommended by educationalists, philosophers, cognitive psychologists, media researchers and instructional designers" (Tergan, 1997 p. 6).

Irene Smith, a professor at the University of Oregon, conducted research in a school that agreed with this rationale and incorporated hypermedia into its curriculum. "In 1984, a large, urban high school created an integrated, interdisciplinary program to help students develop an understanding of the events which have shaped and influenced

United States Culture" (Smith, 1993 p. vii). In 1994, a hypermedia environment was incorporated into this project. In addition to the activities the students performed before, they began to design their own hypermedia documents and used hypermedia tools as another source of information.

Smith (1993) evaluated the students' and teachers' perceptions about the hypermedia learning environment and found that they had many positive insights. Overall, teachers felt that the hypermedia environment enhanced student learning; everyone who participated in the program agreed that it was "advantageous"(Smith, 1993). Students cited a number of reasons why they supported the continued use of hypermedia in the classroom. They were more motivated to produce better work than with traditional methods because peers view hypermedia documents more often than they view traditional work products. They were also motivated by the creativity that designing hypermedia documents allowed them. Moreover, "Students indicated that the nature of hypermedia products promoted a feeling of empowerment" (Smith, 1993, p. viii). Finally, students indicated that they had a deeper understanding of the material as a result of hypermedia and that they had a feeling of satisfaction as a result of becoming experts and sharing information on certain topics.

Although Smith's (1993) data reinforce the theory that using multiple external representations may increase students' learning in the classroom, other empirical evidence demonstrates some limitations. There is a growing body of research literature on the use of hypermedia in schools. Sigmar-Olaf Tergan's (1997) article, "Multiple Views, Contexts, and Symbol Systems in Learning with Hypertext/Hypermedia: a Critical Review of Research" is one such article that synthesizes the research that had been

conducted on hypermedia. Based on his meta-analysis of hypermedia research, Tergan (1997) concluded that hypermedia should only be used under a set of specific conditions (which are discussed below). If the conditions aren't met, the hypermedia environment may not assist the student in learning the subject matter.

Conditions that Tergan (1997) recommends maintaining in a hypermedia environment are the provision of *instructional scaffolding* and *modeling*. Such studies as the ones performed by Jacobsen et al. (1995) and Stark et al. (1995) focused on student learning in two different hypermedia environments. The first conditions provided modeling and scaffolding for the students in the hypermedia environment. The second conditions, the control conditions, allowed the students to roam the hypertext materials freely without any modeling or scaffolding. The students who received guidance while in the hypermedia environment performed at a higher level when asked to transfer knowledge to a realistic problem situation (Tergan, 1997). This suggests that in order to increase student learning in hypermedia environments, educators must provide the necessary instructional scaffolding and modeling.

A more recent meta-analysis that examined studies comparing the effects of hypermedia and traditional instruction on students' achievement found positive evidence to support the use of hypermedia in the classroom (Liao, 1998). Of the 35 studies included in the meta-analysis, 69 percent favored using hypermedia in the classroom over using a traditional instruction approach. Therefore, Liao (1998) concluded, "The results from this study suggest that the effects of using hypermedia instruction are positive when compared to the effects of traditional instruction" (p. 355).

As evidenced above, there is a general agreement among researchers about the effectiveness of using hypermedia in the schools. Smith (1993) concluded that the hypermedia environment increased student learning and improved students' attitudes and feelings about themselves. Tergan's (1997) meta-analysis also demonstrated that a hypermedia environment is beneficial, but only when instructional scaffolding and modeling are present. The most recent meta-analysis published reports that, in general, a hypermedia environment is more effective than traditional instruction (Liao, 1998). Based on the above evidence, it is recommended that pre-service teachers use hypermedia in their classrooms while keeping in mind the conditions under which hypermedia is most beneficial to student learning.

COMPUTER ASSISTED INSTRUCTION

Computer assisted instruction (CAI) has existed for four decades and, therefore, is a component where extensive research has been conducted ("Report to the President," 1997 p. 31). As compared to hypermedia, which has existed only since the late 1980's, CAI is a relatively old research topic (Ayersman, 1996). CAI includes drill and practice, tutorials, simulations and microworlds and virtual reality. "In the classical CAI application, short blocks of instructional material are presented to an individual student, interspersed with questions designed to test that student's comprehension of specific elements of the material" ("Report to the President," 1997 p. 31). The questions are usually asked in a true/false or multiple choice framework and the computer provides feedback on the student's answers to the questions. This section discusses research on CAI, followed by two examples of how CAI improves student content knowledge.

A number of studies have been conducted over the past three decades that assess the effectiveness of CAI in its traditional tutorial-based application. There are several meta-analyses that synthesize the information from many different studies on the effects of using CAI in education. The President's Committee (1997) mentions four such meta-analyses: Hartley (1978), Burns and Bozeman (1981), Bangert-Drowns, Kulik and Kulik (1985) and Kulik, Kulik and Bangert-Drowns (1990). In general, these meta-analyses concluded "students using computer-based systems outperformed those taught without the use of such systems, with the magnitude of the average outperformance computed in

each meta-analysis varying between 25 and 41 percent of a standard deviation" ("Report to the President," 1997 p. 84). The benefits are most noticeable for students of lower socioeconomic status (SES), low-achievers and students with special learning needs. Furthermore, students who partake in CAI generally have a better attitude toward computers, learn faster and enjoy their classes more.

In 1994, James Kulik produced a meta-metastudy. In other words, he analyzed separate meta-analyses that he and his colleagues had completed on computer-based instruction. The generalized findings of the meta-metastudy were much the same as those mentioned above for CAI. The generalizations include: (1) "Students usually learn more in classes in which they receive CAI," (2) "Students learn their lessons in less time with CAI," (3) "Students also like their classes more when they receive computer help in them," (4) "Students develop more positive attitudes toward computers when they receive help from them in school," and (5) Computers do not have a positive effect on student's attitude toward subject matter (Kulik, 1994, p. 11).

A meta-analysis by Yuen-Kuang-Liao (1992) of the University of Houston demonstrates another positive effect that CAI has on students. Liao (1992) examined thirty-one studies conducted on the effects of CAI on students' cognitive abilities. She was curious how CAI affected students cognitive performance or "those skills involved in using cognition to solve problems" (Liao, 1992, p. 368). Such skills include "planning skills, reasoning skills, logical-thinking skills, critical-thinking skills, skills for transferring concepts, and problem-solving skills" (Liao, 1992, p. 368).

Overall, Liao's (1992) meta-analysis concluded that CAI had "moderately positive effects on student cognitive outcomes" (p. 376). She found that CAI does foster the

development of students' cognitive abilities, especially their reasoning skills, logical thinking and planning skills and general problem-solving skills. Liao's (1992) study indicates that students who received CAI "scored about 18 percentile points higher on various cognitive ability tests" than students who did not receive CAI (p. 367). Therefore, in addition to increasing students learning and bettering their attitudes, CAI improves students' cognitive abilities.

The following two studies are more specific demonstrations of how CAI increases student learning. The first study, by Gardner, Simmons and Simpson (1992) focused on third graders' content knowledge of meteorology and attitudes towards science and computers. In the study, a pretest was administered regarding content knowledge of meteorology and attitude towards science and computers to three different groups of students. One group of students was the control group and was taught about meteorology using the traditional lecture, textbook and worksheet method. The second group was taught about meteorology using hands-on activities and the third group was taught using a combination of hands-on activities and the Weatherschool meteorology program software. The software allowed the children to enter in information they had previously collected during their hands-on activity and then autotutorial instruction assisted them in predicting the weather.

The results of the posttest were significantly favorable to using a combination of hands-on activities and CAI to teach about meteorology. "When combining hands-on activities and CAI, the gains from pretest to posttest scores were significantly higher than the gains with the hands-on treatment on both assessments" (Gardner, 1992, p. 336). The authors claim that since this is true regarding science content and attitudes toward

science, a combination of hands-on activities and CAI should be used to teach other content areas in the elementary curriculum. "CAI is one tool that can be employed to help achieve the goals of providing positive and stimulating environments" (Gardner, 1992, 336).

Sim Calc is another example of how CAI can increases students' content knowledge - math in this particular case. Sim Calc is a project that uses "advanced computer technology to introduce elementary and middle school students to basic calculus concepts" also called "the mathematics of change and the rate of change" (Viadero, 1997). An example of how the Sim Calc program teaches students basic calculus concepts is by requiring them "to create mathematical functions to control the movements of animated characters that they see on their computer screens" (Viadero, 1997, p. 1).

Data taken by University of Massachusetts researchers and TERC, a Cambridge Massachusetts research firm, in nine inner city schools where the Sim Calc program was implemented have demonstrated positive results. Elementary and middle school age students who had participated in the Sim Calc program performed "as well as -- or better than typical high school or college age calculus students on problems involving graphical representation of motion or that require the interpretation of velocity-vs. -time graphs, among other calculus skills" (Viadero, 1997, p. 1).

The President's Committee (1997) acknowledges two general benefits of CAI. One general advantage of CAI is that each student can set his or her own pace ("Report to the President," 1997 p. 32). Another advantage is that the computer can determine which content the student does not understand. "Additional time can then be spent on material

with which the student is having difficulty, while avoiding needless repetition of subject matter that has already been mastered" ("Report to the President," 1997 p. 32). The research presented above clearly indicates that CAI improves student learning. Pre-service teachers should remember this when they are planning the curriculum for their classrooms and attempting to achieve the goal of reaching the invention phase.

INFORMATION TECHNOLOGY AND STUDENTS WITH SPECIAL NEEDS

All pre-service teachers will encounter students with special needs in their classrooms. Pre-service teachers must remember that regular students are not the only students who may benefit from the widespread implementation of IT in the classroom. There are also outstanding benefits created by IT for students with disabilities. Computers are allowing students with disabilities to communicate, participate and learn in ways that were previously impossible.

For example, Katherine Montgomery, a 16-year old student with cerebral palsy who attends Falls Church High School in Falls Church, Virginia is able to overcome a writing problem by using IT. Katherine uses a system called Dragon Dictate to "dictate her words into a computer and print them out" (Viadero, 1997, p. 1). Now she does not have to perform the laborious tasks of writing in longhand or typing on a computer to be able to express her thoughts to her teachers. "With her Dragon Dictate, Katherine can keep up with her nondisabled classmates" (Viadero, 1997, p. 1).

The President's Committee (1997) listed several other devices that allow students with many different types of disabilities to keep up with their peers. Students with mobility or sensory impairments may use specialized hardware such as single-finger devices, joysticks or mouthsticks to input information into the computer (1997). Students who are unable to use their hands to type may be able to use "eye gaze" technology, or a "single switch" device with particular keyboard scanning software to choose a row and a

column from a "virtual keyboard" portrayed on the monitor (1997). Also, shorthand and word prediction software decreases the number of keystrokes necessary to type a word. Students with visual impairments have Braille computers, magnification software programs and voice synthesis technology programs that aid them in reading information on the screen or printed documents (1997). There are many other assistive devices for students with special needs, but one particular application encompasses all students with disabilities. This application is the use of the Internet, which provides students with disabilities the chance to communicate with and to learn from other students like themselves.

IT also aids students with low literacy skills. The Peabody Literacy Program is a CD-Rom-based program used to teach students with low literacy skills how to read. The program requires students to view a video and then read about it. An "almost-intelligent" tutor directs students through the program. In other words, the computer determines which activity the student will participate in next based on his or her previous answers and response time. (Viadero, 1997). Researchers at Vanderbilt University in Nashville, Tennessee have tested the Peabody Literacy Program on 5th through 9th graders in Orange County, Florida. "In most cases, they found, students had doubled the reading gains they would normally make at their grade levels" (Viadero, 1997, p. 2).

POSSIBLE BARRIERS TO THE WIDESPREAD IMPLEMENTATION OF INFORMATION TECHNOLOGY

Although the research suggests that IT improves student learning, pre-service teachers must be aware of the many possible barriers that prevent its widespread implementation in the classroom. A partial list of these barriers includes: (1) funding, (2) equality of access, (3) teacher training, (4) infrastructure and (5) access to inappropriate material on the Internet. All five of these barriers are discussed below. There are several possible solutions offered for each of the problems. With these solutions, I believe that the barriers can be overcome.

Funding

During the 1995-1996 school year, public elementary and secondary schools in the United States spent an estimated $3.3 billion on IT (McKinsey and Company, 1995 p. 66). The following is a breakdown of where the money was spent: (1) $1.4 billion for hardware, (2) $800 million for software and other content, (3) $500 million for local interconnection, (4) $200 million for wide area networking, (5) $300 million for professional development and (6) $100 million for systems operation (Presidents Committee, 1997 p. 58). The sum of the amount of money used for IT in education is only 1.3 percent of the approximately $248 billion that was spent during the 1995-1996

school year on public K-12 education. As a result, only $75 of the average per pupil expenditures of $5,623 was spent on IT (Presidents Committee, 1997 p. 58). Unfortunately, this is not enough.

The President's Committee (1997) has determined that in order to improve student achievement, schools must spend somewhere between 2.4 percent and 11.3 percent of their budget on IT. Based on research by a number of experts in the field, the President's Committee (1997) attempted to convert future cost projections into annual cost figures over the next five years. The annual cost projections range from $7 to $15 billion (Harvey, 1995) to $14 to $28 billion (Moursund, 1995). After examining these figures, the President's Committee (1997) recommended that annually at least $13 billion or 5 percent of all educational spending be appropriated for IT related expenditures. This is at least four times the amount currently allocated to IT in education. According to the International Society for Technology in Education ("Information Technology"), the "needed resources will come from a combination of federal, state and local dollars, and through significant restructuring" (1998 16).

Currently, there are several programs and potential programs at the federal level that may provide funding to support the application of IT within American schools. One program funded at the federal level is the Technology Learning Challenge. The President's Committee (1997) describes the Technology Learning Challenge as a program that "awards five-year grants averaging $1 million to local consortia headed by a board of education or other local agency"(p. 105). The program emphasizes content and curriculum, professional development, and the evaluation of educational effectiveness. It also focuses on using IT to improve learning as opposed to learning about IT.

Applications that "serve areas with a high number or percentage of disadvantaged students or other areas with the greatest need for educational technology" are awarded special preference ("Report to the President," 1997 p. 106).

Another funding program that was proposed by President Clinton and passed in Congress in 1996 is the Technology Literacy Challenge. This program consists of a proposed $2 billion Technology Literacy Fund used to "catalyze and leverage state, local, and private sectors" in order to reach the four goals outlined in the *President's Educational Technology Initiative* ("Report to the President," 1997 p. 106). The amount of funding each state receives is determined by student enrollment, but is also subject to a "one-to-one private sector matching requirement" ("Report to the President," 1997 p. 107). The matching requirement could include cash contributions, volunteer time or discounts on products and services.

One of the most important potential sources of funding is the education rate (e-rate) that was created by Congress when it passed the Telecommunications Act of 1996 ("Introducing the e-rate," 1998). "Under this law, schools and libraries can qualify for discounts on a wide variety of networking products, telecommunications services and Internet access" ("Introducing the e-rate," 1998, p. 1). All schools would be eligible for discounts that range from 20 percent to 90 percent of the cost. The discount that the school would receive depends on "whether the school, school district or library is located in an urban or rural area and the economic status of the students or library patrons" ("Introducing the e-rate," 1998, p. 1). The federal government has potentially promised $1.95 billion in order to provide 18 months of service through June 30, 1999. Telecommunications companies that are committed to depositing some of their profits in

the Universal Service Fund will provide the funds. Unfortunately, this is only a potential source and schools have yet to see any of the e-rate money. In fact, this proposed source could still be cut by Congress.

Although it seems like an expensive endeavor to meet all the needs outlined above, return on investment is a factor that must be considered. The President's Committee (1997) predicts a possible "significant" upward shift in the education production

function -- "a curve expressing some measure of educational outcomes as a function of educational expenditures" - due to IT (p. 64). For example, if we invest in today's students, we may see future returns on our investment in the form of lifetime taxable earnings ("Report to the President," 1997). Our country's combined national income depends on whether or not the future citizens of the United States are able to compete effectively in the high-tech global economy. Furthermore, the amount of funding we provide to our public schools for IT related expenditures has a potential impact on the disparity of wealth in the United States ("Report to the President," 1997). If we do not provide funding for all students, it could lead to a small percentage of the population possessing the skills necessary for highly paid jobs while the rest of the population is capable of only unskilled or low-skilled labor.

Equality of Access

One of the questions most frequently asked by reporters is "How should schools deal with the equity issue that exists because many students have access to computers and

technical help at home, and many do not" ("Information Technology," 1998, p. 18)? This is a valid question because students with access to computers and technical support at home have an obvious advantage over those students who do not. Data suggest that there is a large discrepancy in ownership and use of computers due to socioeconomic status, race and ethnicity and even geographic location.

Currently, over 50 percent of households with school-age children own a general-purpose computer ("Information Technology," 1998). On average, these families are most likely of high socioeconomic status (SES). Only 14 percent of households in which the annual income was less than $30,000 owned a computer while 73 percent of households in which the annual income was more than $50,000 per year owned a computer ("Report to the President," 1997). While not as drastic, the discrepancy of computer ownership and use between students of high SES and low SES is also visible in the schools. The poorest schools (those with more than 80 percent of students eligible for funds under Title I of the Elementary and Secondary Education Act) reported only one computer for every 11 students, while the wealthiest schools (those with less than 20 percent of students enrolled in Title I) reported one computer for every 9.5 students ("Report to the President," 1997 p. 70). Furthermore, "Students from families classified as low in socioeconomic status report 14 percent less usage of computers in school than do students from high-SES families" ("Report to the President," 1997 p. 70). President Clinton acknowledged the gap when he announced on June 5, 1998 at an MIT commencement address that "Today affluent schools are almost three times as likely to have Internet access in the classroom" ("Information Technology," 1998 p. 18).

Another important issue surrounding SES is how computers are used in the education of students. Students with a high SES use computers at school for higher order thinking activities, as Constructivists recommend, rather than just for drill and practice as do many low SES students. High SES eighth and eleventh graders were 25 percent more likely than other students to use computers essentially for "higher-order or mixed" activities ("Report to the President," 1997). The President's Committee (1997), in agreement with the Constructivists, believes that, although there is still more research to be conducted, students who use the computer for higher order thinking activities are advantaged in that they will learn more.

Ethnic minorities are also disadvantaged when it comes to IT in education. For example, in 1993, "African-Americans were 57 percent less likely to have a computer at home, and Hispanics 59 percent less likely to have a computer at home, than non-Hispanic whites" ("Report to the President," 1997 p. 75). In addition, schools whose population consists of more than 90 percent minority students have 16 percent fewer computers per capita than other schools in the US (The President' Committee, 1997)

Geographic location may also have a potential impact on the number of computers available for use and the quality of computer use that occurs in schools. Students in rural schools have a 24 percent higher computer-to-student ratio than students who attend urban schools and 40 percent higher computer-to-student ratio than students who attend city schools ("Report to the President," 1997). However, there are potential problems not recognized in the statistics. For example, rural schools may lack the "affordable high-bandwidth telecommunication links" required for Internet access and the technical support that is available in an urban area ("Report to the President," 1997 p. 78).

As evidenced above, there are wide gaps in IT availability and use between students of low SES and students of high SES and between students of various racial and ethnic backgrounds and geographic locations. The President's Committee (1997) warns that "At a time when U.S. income inequality has reached its highest level since 1947, the educational implications of SES-related disparities in home computer ownership should be regarded as a source of serious concern from a public policy viewpoint" (p. 73). If we do not provide the opportunity for equal access to computers for all students, the gap between the various groups may increase. That is why educators and policy makers need to spend more time and money on the problem of inequality of access to computers and use of computers.

The President's Committee (1997) makes several recommendations in light of the problem of inequality within schools. They advise that a minimum set of IT standards should be devised and upheld in all U.S. public schools regardless of the types of students the population is comprised of. ISTE published a model set IT standards in June 1998 ("Information Technology", 1998). Standards such as these can be maintained in schools that serve low SES students by continuing Title I spending for technology related expenditures at its current level with modifications as needs change ("Report to the President," 1997 p. 73).

The President's Committee (1997) also recommends that the Federal Communications Commission should use the authority it received as a result of the Telecommunications Act of 1996 to its full advantage. By doing so, it may provide economically disadvantaged and rural schools with "affordable telecommunication services and wide area network connectivity" ("Report to the President," 1997 p. 73).

Intel's website states that "The e-rate will help to ensure the end of the digital divide between rich and poor schools and among urban, rural, and suburban schools" ("Introducing the e-rate," 1998, p. 1). However, this is only if the program is implemented. Another means to acquire the desired telecommunication services and wide area network for both rural and economically disadvantaged schools is for the government to provide incentives for the private sector in return for the wiring.

It may be more difficult to remedy the problem of computer access outside of school. One means of providing students with access outside of schools is to increase the provision of computers and Internet connectivity open to the public in libraries, community centers and other public institutions. Another approach is to increase the hours that computers at schools are available to the students by providing access after school and on weekends.

Possibly the best solution to the problem of home access is to provide students with laptops that they can use at school and at home. Several experimental pilot programs have allowed students to borrow laptops to take home. Although these programs are expensive the results have been "quite promising" ("Report to the President," 1997 p. 75).

The President's Committee (1997) recommends two methods that would potentially decrease the cost of programs like these in order to make the provision of laptops to students without home access a realistic public policy goal. One method is to use television sets as monitors as most families in the United States own a television. The second method is to wire all newly constructed federal housing projects so that they will be capable of "supporting future network needs in a cost-effective manner" ("Report to the President," 1997 p. 75).

Teacher training

"A teacher might use technology poorly, use it well, or not use it all" says Ted Hasselbring, co-director of Vanderbilt University's Learning and Technology Center (Viadero, 1997 p. 2). What it may all come down to is whether or not the classroom teacher uses IT effectively to improve learning in the classroom. Currently, of the teachers who have one or more computers accessible to them in their classroom or at their school, only 62 percent use computers regularly for instruction ("Report to the President," 1997). Furthermore, many of the teachers who do utilize the computer for instruction use it only for drill and practice of isolated skills or for teaching how to use a computer. Why is this occurring? "Teachers commonly report that they have not received adequate preparation in the effective use of computers within the classroom" (Office of Technology Assessment, 1995 p. 48).

As of now, only 15 percent of the IT budget is allocated to professional development ("Report to the President," 1997 p. 48). Experts in the field recommend that in order for a school's computers to be used properly and efficiently, 30 percent of the IT budget must be allocated to professional development ("Information Technology," 1998). In my opinion, the lack of teacher training is one of the most important barriers to the widespread implementation of IT. If schools spend a large portion of their budget on hardware, software and connectivity and a small portion of their budget on teacher training and support, then only those who teach themselves or those who learn in pre-service programs will be able to utilize IT to improve student learning.

When teachers actually do receive training, it is often a negative experience. One survey found that 46 percent of educational IT courses are given as half-day workshops and 79 percent of these courses focus on hardware, Internet usage, or a specific piece of software (Siegel, 1995). Instead of learning how to use IT to strengthen student learning, teachers are being instructed in how to use a computer. The President's Committee (1997) concludes that teachers are "Generally unprepared to handle the diverse logistical and curricular challenges they encounter within a technology-rich environment" (p. 49).

The President's Committee (1997) makes many recommendations regarding the implementation of professional support. If 30 percent of the IT expenditures were spent on professional development, teachers would be able to receive the training needed to transform a classroom from a traditional classroom to one that makes effective use of IT to increase student achievement. In addition to training, teachers should receive support in the form of technical assistance as well as assistance in effective teaching methods. Specifically, "Teachers should be provided with ongoing mentoring and consultative support and with the time required to familiarize themselves with available software and content, to incorporate IT into their lesson plans, and to discuss IT with other teachers" ("Report to the President," 1997, p. 8).

To obtain these goals, the President's Committee (1997) has offered several suggestions. The first is that each school has a full-time computer coordinator who provides on-site assistance to teachers and students. In 1993, less than five percent of schools had a full- time computer coordinator (Palmer, 1993). Other options, though less optimal, are to prepare a staff at the district level to provide support or to intensely train several teachers at each school who can serve as support for their colleagues.

IT itself may help educators reach some of the goals outlined above. Educational software, as has software in general, will probably become more user friendly and therefore will require less extensive demands on the teacher ("Report to the President," 1997). Educational software may also provide the teacher with more time because when using educational software students may require less attention from the teacher. Furthermore, IT may allow the teacher to consolidate time-consuming aspects of his or her everyday schedule such as "facilitating the development of instructional materials, the recording and assessment of student progress, and access to various forms of information resources" ("Report to the President," 1997 p. 51). With this extra time, the teacher has more time to plan and develop instruction around IT.

Again, IT in the form of information sources may help to provide the teacher with the support that is needed to implement IT in the classroom. Online seminars over the Internet may cut the cost of traditional seminars and make it possible for teachers to receive consultations and mentoring after the seminar on an ongoing basis ("Report to the President," 1997 p. 51). Moreover, the Internet provides teachers with the opportunity to share ideas, lesson plans and curricular materials.

The publishing company, ISTE, suggests a different solution to providing teacher support ("Information Technology", 1998). A federally funded 5-year Challenge Grant program in Olympia, Washington is exploring an interesting idea. Students are instructed on how to be resources for their teachers and other students. According to ISTE (1998), there is a substantial amount of evidence that students acting as tutors for their classmates "empower students" and is an "effective aid to student learning" ("Information Technology," 1998, p. 27).

Teachers reported that the largest obstacle to implementing IT in the classroom was a lack of sufficient time to develop lessons that use computers (Sheingold & Hadley, 1990). To remedy this problem, the President's Committee (1997) recommends that 2 hours per week be set aside for technology-related curriculum design. However, this solution creates its own problems. "The problem of insufficient teacher time encompasses both a logistical question (how to restructure the school day to give teachers time to develop IT-related teaching skills) and an economic question (how to pay for the additional time associated with IT-related professional development and class preparation)" ("Report to the President," 1997, p. 53). Although providing teachers with the necessary support and planning time may be an expensive endeavor, it is one that is necessary.

Unfortunately, the problem of teacher training also pertains to future teachers. ISTE ("Information Technology," 1998) and the President's Committee (1997) both agree that teachers in training receive less than adequate preparation in the area of IT in the classroom. Although many teacher education institutions are providing training in the use of IT in the classroom for future teachers, ISTE ("Information Technology," 1998) claims the research implies that "perhaps less than half of these students are being adequately prepared to deal with IT in today's schools" (p. 21). Eighteen states actually require Colleges of Education to provide some pre-service IT training, but the requirements are easily fulfilled by courses that do not teach any practical applications for the classroom ("Report to the President," 1997). The Office of Technology Assessment (OTA) synthesized the information on the state of teacher education programs into a single

statement: "Overall, teacher education programs in the United States do not prepare graduates to use technology as a teaching tool" ("Teachers and Technology," 1995 p. 54).

It is necessary to change the situation in teacher training programs from its current state. As the President's Committee (1997) claims, "Colleges of Education have a valuable opportunity to introduce future teachers to the use of IT before the demands of an actual teaching position begin to impinge on the time available for such training". Educators need to take this advice to heart and develop curricula to prepare teachers to use technology.

The curriculum recommended by Willis (1997) may be a model for doing so. In her article, "Technology: Integrated into, Not Added onto, the Curriculum Experiences in Pre-Service Teacher Education," Willis (1997) summarizes two models of technology integration found in the literature on pre-service teacher education. One model calls for integrating technology "into the college curriculum, with professors modeling its use and training activities centered around the use of technology" (Willis, 1997, p. 145). Another model found in the literature "is that of a required computer integration course for all pre-service teachers that might include computer-literacy applications such as word processing, database and spreadsheet" (Willis, 1997, p. 145).

Although it seems that it would be fairly simple to give pre-service teachers the training they will need incorporate IT into their classroom curriculums, Colleges of Education claim a number of problems similar to the problems that public elementary and secondary schools are encountering. First and foremost is a lack of funding. "Many teacher education programs indicate that they are not being adequately funded to effectively deal with IT" ("Information Technology," 1998, p. 21). Another familiar

problem is insufficient professional development ("Report to the President," 1997). IT in education is a rapidly changing field that requires university professors to be constantly learning also. A final problem mentioned by Colleges of Education is "a lack of time for professors of education to restructure their courses" ("Report to the President," 1997, p. 54).

One solution to all three of these problems is additional funding. It appears that any funding the Colleges of Education will receive to improve their courses on IT in education will be provided by the federal government. Unfortunately, a recent report from Washington says that a bill to provide money for Colleges of Education is unlikely to be funded during the coming year.

Infrastructure

Yet another barrier to the widespread implementation of IT in the public schools is providing the necessary infrastructure within the schools to do so. Many schools were built long before computers were part of education. Therefore, these schools' infrastructures do not meet all of the current needs. Problems include the fact that the AC wiring in the old schools cannot support the number of computers being installed today. Furthermore, most schools were not intended to accommodate the physical cables necessary for data transmission on which the local area networks are based. Many schools lack the external connections required for Internet access and other wide area networks. Finally, a significant number of computers in the same room radiates enough heat to require air conditioning in schools that do not have it and additional cooling systems in

schools that do. Adding to the already laborious process of providing the necessary infrastructure is the asbestos in some schools' walls, which increases the difficulty of properly wiring the schools ("Report to the President," 1997 p. 25).

Connectivity is a continuing problem. However, the President's Committee (1997) offers several solutions. One potential aid for providing the necessary infrastructure in schools is the e-rate. Infrastructure is also an area where community members can be extremely helpful. During Net Day 96, volunteers in California wired a large number of schools for Internet access ("Report to the President," 1997). Since providing infrastructure requires a great deal of funding, one way to save money is to plan ahead and wire for the future while wiring for the present. On the topic of providing funding for the necessary infrastructure, the President's Committee (1997) again says "that such expenditures represent an important investment in the future of the American public school system that is warranted by the associated economic and social returns that can reasonably be expected" (1997, p. 26).

Access to Inappropriate Material on the Internet

There are a number of sites on the Internet that are inappropriate for the eyes of children in our schools. According to ISTE ("Information Technology," 1998), many schools are using one or two approaches to protect their students from visiting these sites. The first approach is an Acceptable Use Policy that ensures that students do not "make use of the Internet until they and their parents understand the policy and agree to abide by it" ("Information Technology", 1998, p. 19). The second approach includes installing

software that can screen out access to inappropriate Web sites. Other recommendations for keeping students away from inappropriate Web sites include supervising students closely and educating them about inappropriate sites ("Information Technology," 1998 19). "Veteran Internet educators say that helping students weed out the bad information can become a lesson on critical thinking" (Viadero, 1997, p. 3).

However, none of these methods is always adequate. ISTE ("Information Technology," 1998) states that many schools use the screening software "even though it is far from foolproof or 100 percent effective" (p. 19). Richard Bentz, a high school biology teacher in Wickliffe, Ohio, expresses his concern that the screening software may also censor out the educational material. He wonders "If I have students doing research on breast cancer, will that be knocked out because of the word 'breast'" (Viadero, 1997, p. 3)?

CONCLUSION

Pre-service elementary and secondary teachers may draw many conclusions about the use of computer technology in the classroom based on this synthesis of information. Research demonstrates that there are many effective ways to improve student achievement with IT. Therefore, it is recommended that pre-service elementary and secondary teachers incorporate IT into their classroom curriculum when they become teachers with the goal of reaching the invention phase.

According to the experts in the field, general purpose, generic tools, information sources, hypermedia/multimedia and CAI could have a positive impact on students' learning. The empirical evidence demonstrates that using these four components of student productivity in the classroom increases students' learning. (Schramm, 1991; Bangert-Drowns, 1992; Viadero, 1997; Smith, 1993; Tergan, 1997; Gardner, 1992; Kulik, 1994; Liao, 1992; Peck and Hughes, 1997; Viadero, 1997). Future teachers should examine the IT that has proven to work and implement it in their classrooms.

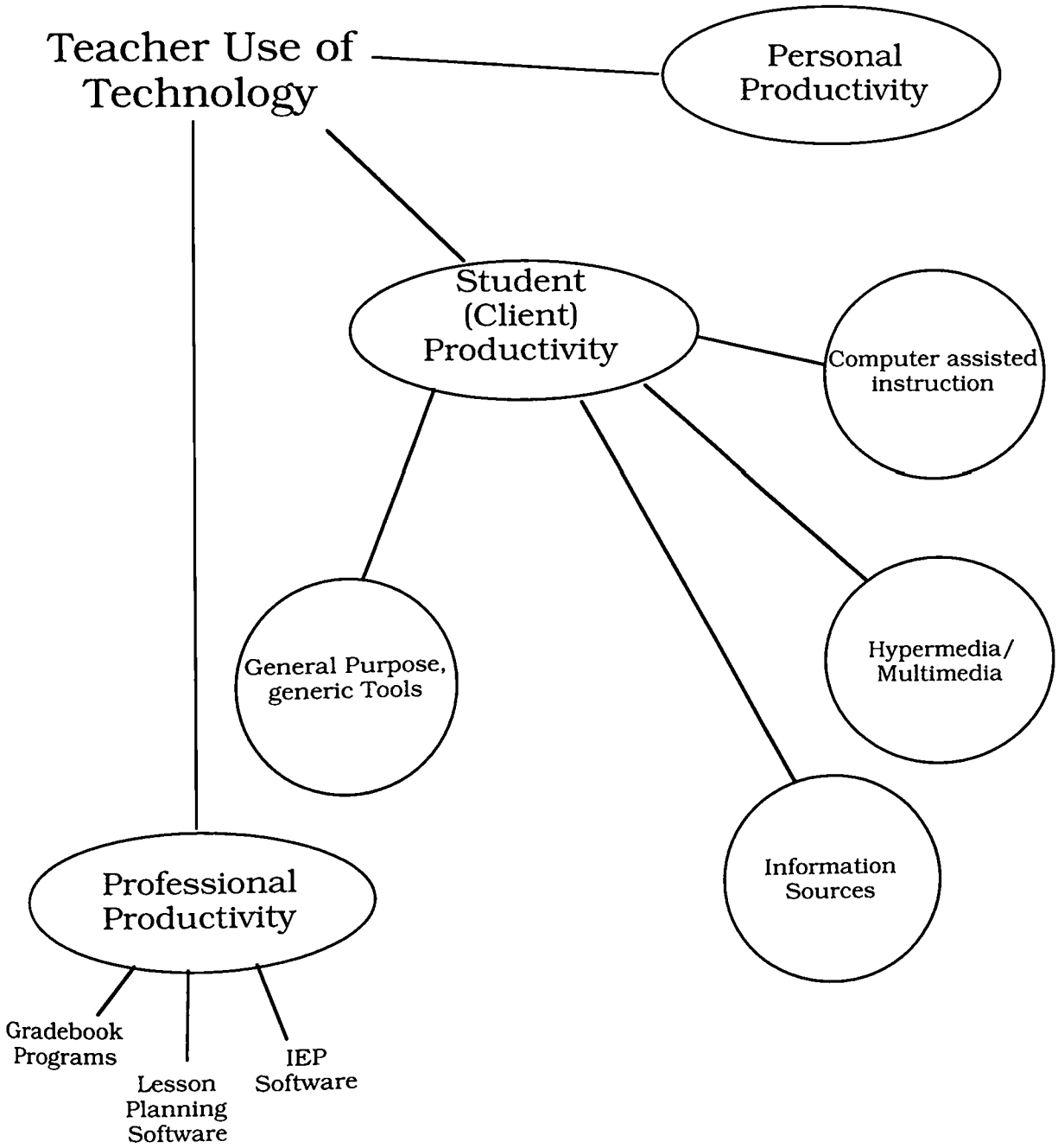
Another conclusion that pre-service elementary and secondary teachers may make based on this synthesis of information is that more research must be conducted. Most researchers make some sort of recommendation for future research at the end of their journal articles. After completing her study, Liao (1992) claims that "Left unanswered is the question of whether CAI is as efficient, or any more efficient, at developing the cognitive abilities than are other instructional approaches" (p. 377). Research on how to

help students learn to make effective use of the emerging Global Library is especially needed.

Unfortunately, educational research is one of the most underfunded aspects of education. Less than 0.1 percent of the total amount spent on K-12 public education is allocated for determining which techniques in education are effective and how to improve them (Presidents Committee, 1997). The President's Committee (1997) recommends that in order to effectively research the topic, the states and the federal government should steadily increase the percentage of their budget spent on educational research until the amount reaches and remains steady at 0.5 percent or approximately $1.5 billion per year at present expenditure levels.

Funding is perhaps the largest barrier to the widespread implementation of IT in the classroom. Other barriers are inequality of access, teacher training, infrastructure and access to inappropriate material on the Internet. However, it is possible to overcome these barriers; several suggestions for doing so are mentioned above. Pre-service teachers can help overcome these barriers by campaigning for and supporting the provision of funding, equality of access, teacher training and infrastructure. They will have a substantial influence on policy makers and the activities in classrooms; therefore, they will have the power to improve the educational achievement of today's children in the United States.

APPENDIX A


Teacher Use of Technology
Personal Productivity
Student (Client) Productivity
Computer assisted instruction
General Purpose, generic Tools
Hypermedia/ Multimedia
Information Sources
Professional Productivity
Gradebook Programs
Lesson Planning Software
IEP Software

APPENDIX B

Technology and You, the Teacher

Later in this course you will be reading a research article about the phases teachers go through as they integrate technology into their teaching. Below is a list of these five stages with a brief explanation of each stage.

If you were to begin teaching right now, where on this scale do you think you would be in your use of technology in the classroom. Put an "X" in the column that you think fits you best now. Then put a "?" where you think you'd like to be by the time you begin to teach.

Phase	Brief Description	You!
Entry	Use traditional materials and then technology "arrives" in their classrooms. Teachers then begin to use the technology but also encounter management and resource problems.	
Adoption	Use computers to support traditional instruction. Most computer use remains traditional—drill and practice, simple tutorial, etc.	
Adaptation	Use computer for such tasks as word processing, databases, spreadsheets, etc. Productivity of students and teachers becomes a focus.	
Appropriation	Comfortable enough with the technology to try new ideas. Teaching methods incorporate technology in a wide variety of ways. Movement away from only traditional ways of using technology.	
Invention	Use technology, both current and emerging, to enhance teaching and learning; see the technology as a tool to be used wherever appropriate as children take a great deal of responsibility for their learning.	

Your name: _____

GLOSSARY

Gradebook programs- programs that do the tasks that a teacher has done in the past with a paper and pencil. This includes recording of grades, computing grades, taking attendance, making seating charts, reporting grades to students and parents etc.

Global Library-"The libraries of the world are being networked together and their contents are being digitized. The totality of these print and digital library resources can be thought of as a Global Library" (Moursund, 1995)..

Individualized Education Program (IEP)- Written document required by the Individuals with Disabilities Education Act (PL 94-142) for every child with a disability.

Individualized Education Program software- software that allows a teacher to more easily develop and manage an IEP. The software has a standardized format already set up and often includes standard objects that can be easily inserted.

Instructional scaffolding- occurs when the teacher provides support when a skill is being introduced and gradually takes away the support as the students learn to use the skill independently.

Lesson planning software-software that helps a teacher create and manage day to day lessons as well as using planning and keeping track of the school calendar.

Meta-analysis- refers to the "statistical analysis of a large collection of results from individual studies for the purpose of integrating these findings" (Kulik, 1994).

Modeling- occurs when the teacher demonstrates a skill in order to prompt students on how to use it.

President's Educational Technology Initiative- The President's initiative regarding educational technology. It was formulated with the aim of ultimately achieving four top-level goals in the area of computers, connectivity, content and educators.

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