DOCUMENT RESUME

ED 473 018 IR 021 660

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TITLE	Effective Technology Integration: A Plan for Professional Development.
PUB DATE	2002-06-01
NOTE	98p.; Master's Thesis, Cedarville University.
PUB TYPE	Dissertations/Theses - Masters Theses (042) -- Tests/Questionnaires (160)
EDRS PRICE	EDRS Price MF01/PC04 Plus Postage.
DESCRIPTORS	*Computer Uses in Education; Constructivism (Learning); *Educational Technology; Faculty Development; Grade 6; Group Activities; *Instructional Effectiveness; Intermediate Grades; *Mathematics Instruction; Pretests Posttests; Student Motivation; Student Surveys; *Technology Integration
IDENTIFIERS	Christian Schools

ABSTRACT

Is educational technology effective in increasing student learning? If technology is an effective tool in the classroom, how can teachers best be trained to use it appropriately? An experiment was conducted to determine the effectiveness of a constructivist math class utilizing computer technology as well as other tools. The study occurred in a Christian school in Northern Kentucky using 51 sixth grade students. One class comprised the control group, with math instruction that differed little from the traditional background of the school. The other class was the experimental group, which used the Internet, spreadsheets, word processors, and measuring devices to learn in a hands-on environment. Two math units were used in the 6-week study. A one-way ANOVA test showed no significant difference in the first unit scores. The one-way ANOVA test of the second unit showed a significant difference in favor of the control group. Despite these results, the researcher was not discouraged, primarily because chi-square tests of a survey given to students in the experimental group overwhelmingly showed positive motivation in math during the study. Appendices include instructions for group activities and a copy of the student survey. (Contains 33 references.) (Author/MES)

EFFECTIVE TECHNOLOGY INTEGRATION:

A PLAN FOR PROFESSIONAL DEVELOPMENT

A thesis submitted in partial fulfillment
of the requirements for the degree of
Masters of Education

By

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ABSTRACT

Dunlap, Craig G. M. Ed., Education Department, Cedarville University, 2002. Effective Technology Integration: A Plan for Professional Development.

Is educational technology effective in increasing student learning? If technology is an effective tool in the classroom, how can teachers best be trained to use it appropriately? An experiment was conducted to determine the effectiveness of a constructivist math class utilizing computer technology as well as other tools. The study occurred in a Christian school in Northern Kentucky using fifty-one sixth grade students. One class comprised the control group, with math instruction that differed little from the traditional background of the school. The other class was the experimental group, which used the Internet, spread sheets, word processors, and measuring devices to learn in a hands-on environment. Two math units were used in the six-week study. A one-way ANOVA test showed no significant difference in the first unit scores. The one-way ANOVA test of the second unit showed a significant difference in favor of the control group. Despite these results, the researcher was not discouraged, primarily because chi-square tests of a survey given to students in the experimental group overwhelmingly showed positive motivation in math during the study.

CEDARVILLE UNIVERSITY

SCHOOL OF GRADUATE STUDIES

June 1, 2002

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Craig George Dunlap ENTITLED Effective Technology Integration: A Plan for Professional Development BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Education.

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ACKNOWLEDGEMENTS

I would like to thank all those who helped me as I wrote my thesis.

First and foremost, I would like to thank the Lord for giving me all good things, not the least of which were endurance and wisdom as I worked on this thesis.

To Cheryl Ellington and the 2001-2002 sixth grade students at Calvary Christian School, thank you for helping by taking part in my experiment. Thank you for putting up with me as I had the pressures of this major project. I also want to thank my student helper, Faith Stephenson, for taking a lot of my work on her shoulders so that I would have more time for research and writing.

Thank you to all my professors at Cedarville University who helped me to take a different look at how teaching should be done. I want to especially thank Dr. Ed Baumann for making me work hard to learn not just facts but how to think. I also want to give special thanks to Dr. Stephen Gruber for his patient help as I pestered him with questions throughout the thesis-writing process.

I would also like to thank Doug DeCamilla for his help throughout the research process. He was an incredible help by recommending sources, asking me good questions to help me focus my topic, and fueling me with excitement for the whole process.

Thanks also go to my parents, Richard and Eleanor Dunlap, and my mother-in-law, Linda Barabas, for being a constant encouragement.

Rick Schrenker deserves immense gratitude for being my proofreader. Thank you!

DEDICATION

I want to dedicate this thesis to my wonderful wife, Celeste Dunlap. Celeste was my constant companion and encourager throughout graduate school. She helped me constantly with this thesis, listening to me ramble on about computers, ACOT, and constructivism. She did all this while working on her own thesis and teaching full time, as well. Celeste, I love you. Thank you for all your help. Let's go to Alaska!

CHAPTER I: Introduction

There are many resources available for the technologically astute teacher. If one considers technology to include cable television, VCRs, DVDs, computer programs, and the Internet, teachers have a lot of technology at their fingertips, assuming their schools have the funds to place these things in the classroom. However, how many teachers are properly trained to use the technology that has been provided for them?

The technology that is available to educators can be divided into three types of tools: teacher tools, presentation tools, and interactive tools. Teacher tools are applications that teachers use to help them behind the scenes. These can include grade book programs, web sites for lesson plans, and researching that may be done prior to teaching. On the other hand, presentation tools can be defined as programs that teachers use to present material to the students. Many teachers use Power Point presentations as they teach their classes. Other teachers may project a web site on a screen to assist in teaching a lesson. Another aspect of teaching using technology is the last category, interactive tools. It is through these tools that students become active participants in technology. Students do their own research on the Internet or through CD-ROMs. They can communicate with other students around the world and learn about other cultures. Students can use these tools to present what they have learned. Students use tutorials, either on disk or on the Internet, which can reteach content or enhance learning.

Is educational technology effective in increasing student learning? If technology is an effective tool in the classroom, how can teachers best be trained to use it appropriately?

Many schools, districts, and states have poured thousands and millions of dollars into technology. Most classrooms have at least one computer, if not miniature computer labs. Huge computer labs are not uncommon in many American schools. Classrooms are hooked up to the Internet. The technology is there, waiting to be used, but few teachers may know what to do with it all. While these schools have worked hard to bring the technology to the classrooms, many may not have made the extra effort needed to bring the teachers to the technology.

Training may be needed for teachers to learn how to use a computer. Many teachers grew up in a world where computers were not a part of every household. Even educators who were trained in high school or college in simple programming or word processing may not always feel comfortable using higher level applications. Before teachers can integrate technology into their teaching, they need to be familiar with the technology.

While it may be important to train educators how to use a computer and how a computer can make their lives easier, teachers might need to learn how to put the computers in the hands of the students so that they can learn how to use them too. With the recent exponential growth of technology, it is evident that the work force of the future should be computer literate. Unless students learn how to use computers from a very early age, they may be left out of this job market. Most likely this will not happen until teachers know how to use the computers themselves and allow students to use the computers, too.

Many researchers feel that teachers should not just put the students in front of a computer and let them have fun. Instead, they believe that computer use should be integrated into the curriculum. The argument is that there ought to be a purpose driving the computer use. Likewise, many feel that everyone should be given a fair chance to learn about computers and use them equally. Girls must be given the same opportunities as boys. Similarly, those from a lower-socioeconomic group need the same chance as those from higher-socioeconomic levels.

God created Adam and Eve and commanded them to "fill the earth and subdue it. Rule over the fish of the sea and the birds of the air and over every living creature that moves on the ground," (Genesis 1:28). In order to subdue and rule over the earth, Adam and Eve had to learn how this new creation functioned. While Genesis is not clear on how Adam and Eve learned, it is evident that God gave them the entire Garden of Eden to explore. As they explored and lived in the Garden, Adam and Eve had certain problems that came up. Perhaps they found a river that had to be crossed. Together, they would have worked to solve the problem by building a new tool, maybe a boat or a bridge. These tools helped Adam and Eve learn how the world worked so that they could be better stewards and caretakers of it.

However, God did not just let them explore and hope that they would learn something useful. Genesis 3:8 makes it appear that God would spend time with them in the evening. While we can only speculate about what they discussed, it would seem that they must have talked about what happened that day. Most likely, God would have given them advice on things that they learned and tools that they made that day. In other words, God led them in their discovery.

Now, thousands of years later, mankind still lives under that mandate of subduing, or taking care of, the earth. Exploration of God's creation is still needed to see how it functions, maintaining the need for new technology to help us in this quest. What used to be crude technology in the first days and years of the world, has been replaced by more modern technology. Computers could be tools to help learn more about God's creation and to fulfill the command to subdue it. Therefore, it may be important that students learn about the world and to use computers to solve problems that arise around them. Likewise, teachers should not just assume that students are learning something beneficial. Students may need to be guided in their learning, even with computers.

Technology integration may need to be more than students passively watching a presentation that a teacher made. Instead, today's students may need to be active participants in the growing technology surrounding them. Computers might not be learned by observation but could be mastered through interaction.

Educators who are interested in integrating technology into their curriculum could benefit from reading what works in classrooms, observing and talking with their peers who have been successful with computer integration, getting student opinions, and experimenting to find what best fits their curriculum.

This thesis will analyze research made by various educators and technology experts on how technology can be used in the classroom. Information will be gathered from a few different sources, such as Pennsylvania's Link-to-Learn web site and recommended sources from Douglas DeCamilla, a third grade teacher and technology integrator in Maine. It will also look at the effectiveness of teaching using interactive technological tools by experimenting with the sixth grade math curriculum at a moderately-sized Christian school in Northern Kentucky. It will also look at the results of a survey taken by the students in the experimental group gauging their motivation level during the experiment.

CHAPTER II: Review of Literature

Computers are tools that can be used to accomplish a myriad of tasks and achieve any one of a number of goals. They can be used to promote higher order thinking skills or to play mindless games. However, research tends to indicate that technology is not being used appropriately in today's classrooms (Kleiman, 2000; Glennan & Melmed, 1995).

One way that this tool can be used is as a catalyst for change. Researchers have found that when a classroom is immersed in technology, many things begin to change in the classroom. Teacher/student relationships change as teachers get away from the role of instructor and begin to come alongside the student as facilitator or coach. This is a result of a change in the way that teachers teach, moving from traditional instruction with lecture, drill-and-practice, and rote memorization of facts toward a constructivist model which promotes active student learning through inquiry, problem solving, and collaboration with peers and adults. However, these are not the only changes technology can bring to the classroom. Technology integration, done correctly, can lead to success for everyone (Apple Classrooms of Tomorrow, 1995).

In 1996, President Clinton and Vice-President Gore introduced the purpose for technology integration in the Technology Literacy Challenge. The reason for technology in the classroom is not to provide state of the art equipment for its own sake. Instead, the role of technology is to increase student achievement by using this tool (Wenglinsky, 1998).

Many states have invested millions of dollars into technology. In 1996, Pennsylvania launched a three-year program named Link to Learn, a project costing $109 million (Yakel & Lamberski, 2000). The goal, according to Governor Tom Ridge, was to "keep Pennsylvania educationally and economically competitive in a world that increasingly relies on technology," (Commonwealth of Pennsylvania, 1998). More specifically, the commonwealth wanted to assist schools in getting technology, to change education so that it extended beyond the walls of the schools, to give teachers resources and abilities to integrate technology in their classrooms, to enable schools and libraries to become technology resource centers for the community, to promote technology standards in education, to encourage collaboration among school districts, and to link together school, home, and community. Before receiving funds, schools were required to create an educational goal that the technology would help achieve, to provide for professional development, and to promise to share their technology resources with the community (Commonwealth of Pennsylvania, 1998).

Rhode Island launched the Rhode Island Teachers and Technology Initiative (RITTI) in 1997, by providing laptop computers and sixty hours of training to twenty-five percent of the teachers in Rhode Island. The initiative had three short-term goals: to help teachers become more productive personally, to encourage communication and collaboration between teachers, and to enable teachers to create their own curriculum.

The long-term goal was to improve student learning. The hope was that these teachers would be a voice among educators to push for more technological advancement (Thorpe, 1999).

The state of Maine has formed a partnership with Apple, Inc. to provide technology in their schools. Starting in spring 2002, Maine and Apple will provide every seventh grader in the state with a laptop that, while belonging to the school, can be used by individual students throughout the year. The goal is to bring equity to educational technology in Maine by ensuring that all students will have the opportunity to learn how to use computers through real-life situations. Like Pennsylvania, Maine is hoping to reap economic gain from the Laptop Initiative. "If Maine has the most technologically capable workforce and the most technology-savvy schools in the country, we are confident the economic benefits will follow," (Task Force on the Maine Learning Technology Endowment, 2001). This is not a one-time purchase. Maine eventually plans to buy laptops for every eighth grade student the following year and to add to the collection each subsequent year (Task Force on the Maine Learning Technology Endowment, 2001; D. DeCamilla, personal communication, January, 20, 2002).

These are only three examples of what states are doing to boost technology use in schools. In 1985, the computer to student ratio was 125 to 1. By 1995, that ratio changed to 9 to 1. In 1994 alone, American schools spent three billion dollars on technology (Glennan & Melmed, 1995). Since so many states and schools have spent vast amounts of money bringing technology into the classrooms (Robelen, 1999; Wenglinsky, 1998), it would be financially wise to ensure that the technology is being used to fit this goal.

In 1991, the United States Department of Labor stated important skills for tomorrow's workforce. They listed thinking skills, such as "the ability to learn, reason, think creatively, make decisions, and solve problems," and personal qualities, such as "individual responsibility, self-esteem and self-management," as the necessary characteristics for future workers (Rein, 2000). Research and Development (RAND), a non-profit research organization, tends to agree with this claim. They listed the needed characteristics of future workers as basic language and math skills, ability to gather and use information, collaboration, and problem solving (Glennan & Melmed, 1995). These skills can be achieved using technology as a tool, if the technology is used the right way (Aiken & Aditya, 1997; Glennan & Melmed, 1995). In order to be wise stewards of the money spent, it would be prudent to explore technology's effectiveness in the classroom and, if it is effective, the best ways to teach using technology.

Before exploring the studies on the effectiveness of educational technology, it is important to note that researchers have identified three limitations to the present body of research. First, studies have shown a positive impact of technology integration but only in specific conditions. Second, these specific conditions lead to a need for careful interpretation before results are applied generally across the curriculum. Third, technology is a rapidly changing field. Because of that, research methods change rapidly, also (Kimble, 1999).

Computer assisted instruction (CAI) has been used in schools since the 1960s (Wenglinsky, 1998; Glennan & Melmed, 1995). It found its origin in educational philosophy based on B. F. Skinner's work (Glennan & Melmed, 1995). This form of drill-and-practice instruction has proven effective in a number of studies. Students with CAI tend to do better on standardized tests than those who do not use CAI (Wenglinsky, 1998). While drill-and-practice has evolved over the decades, it is still widely used in schools today. In fact, it is still the most frequently used application in American elementary schools (Glennan & Melmed, 1995).

According to RAND, most of these studies have been done on small scales using limited settings. However, when put together as a whole, the research creates a large body of literature that seems to suggest that technology wields power that can be used in a number of situations. What is lacking in the current research is a study on entire schools that have made the effort to integrate technology into the curriculum of the whole school (Glennan & Melmed, 1995).

James A. Kulik, cited in the RAND study, performed a meta-analysis, an analysis of a large number of research studies, on the effects of computer integration, using primarily drill-and-practice software. He found that when students learn from a computer-based instruction, they tend to learn more in less time. They also develop positive attitudes about computers and the class in which they use computers. However, even though students like classes more when computers are used, computer use does not better students' attitudes toward the content of those classes (Glennan & Melmed, 1995, Unfortunately, the researcher could not find a copy of this report.). These findings seem to suggest that computer-based instruction reaps positive gains in the education of children, since four out of five measures display beneficial outcomes.

With a shifting focus from the traditional approach to teaching to the constructivist style, educational technology use is also beginning to shift away from CAI (Aiken & Aditya, 1997). Instead, more research is being done on how higher order thinking skills can be taught with technology.

One such study, which is widely cited in other research projects, is the Apple Classrooms of Tomorrow (ACOT) project. In 1985, Apple, Inc. researchers asked themselves, "What happens to students and teachers when they have access to technology whenever they need it?" (Apple Classrooms of Tomorrow, 1995). Apple, Inc. formed an alliance with elementary and secondary schools and universities as they studied the answer to that question. They selected five classrooms across the United States of America and gave each teacher and student two computers, one for school and one for home. Teachers were given some training in using applications. Then they watched what would happen. ACOT researchers not only claimed success, but they also saw their teachers change from using a traditional teaching style to a constructivist style. Students were engaged in activities that promoted not just technology use, but higher levels of learning and collaboration. Based on standardized test scores, teacher comments, and observations by educational experts, ACOT researchers claimed that students improved their performance in a number of areas. Even though students had to learn how to use the technology, which took away from content teaching time, test scores showed that students were performing as well as or better than if they did not have the technology. Students became better, more effective, more fluid writers. Some units of study were actually finished more quickly than before technology was introduced. In fact, ACOT researchers found that students were developing abilities that are not evaluated on traditional assessments and new assessments had to be created to judge their growth (Apple Classrooms of Tomorrow, 1995; Sandholtz, Ringstaff, & Dwyer, 1997).

According to the ACOT study, technology can be effective if it is used the right way. If computers are used to increase collaboration, exploration, problem solving, social awareness, and independence; students can benefit from using them in the classroom. If computers are highly integrated into the curriculum, then computers can be used effectively (Rein, 2000).

Harold Wenglinsky (1998) of the Educational Testing Service (ETS) used data collected from the math section of the National Assessment of Educational Progress of 1996 and a questionnaire that was completed by students, teachers, and administrators to analyze a number of different questions about computer usage in schools. Wenglinsky was particularly interested in "student access to computers in school for mathematical tasks; student access to computers and frequency of computer use at home; preparedness of mathematics teachers in computer use; and the ways in which the mathematics teachers and their students use computers," (Wenglinsky, 1998). These studies involved fourth and eighth grade students from across the nation and from all socio-economic groups, all ethnicities, and both genders. Across the country and in both grades, computers were most often used for lower-order thinking, like drill-and-practice activities (Wenglinsky, 1998; Fulton & Torney-Purta, 2000). However, a deeper look at the data shows that urban minority students from a lower socio-economic background use computers for drill-and-practice activities more frequently than suburban White students from higher socio-economic backgrounds (Wenglinsky, 1998).

However, Wenglinsky also found that those students in either grade who used computers primarily for higher-order thinking activities did better on the math section of their tests. In addition, he found that in eighth grade, lower-order thinking skills were negatively related to mathematic achievement. The data seems to suggest that if computers are used to teach higher-level thinking, then students will be better math students. In addition to standardized math scores, Wenglinsky's study found that technologically rich schools gain in other areas such as student motivation and morale (Wenglinsky, 1998).

Teaching with technology, when used appropriately, can bring about benefits other than higher grades. Students tend to be more engaged and involved in their own learning. Technology can be effective, because it brings about positive attitudes toward learning and encourages success for low achievers. When students are actively involved in using computers, they are actively involved in their own learning. With more involvement comes more learning. Technology can help rid the classroom of passive learning because interactive computer use forces students to make decisions and live with the consequences of those decisions. However, computer use must be done effectively. That requires careful planning on how it will be implemented. Applications must be selected that will promote learning and reach individual students where they are (Hancock, 1993).

J. D. Fletcher, cited in the RAND study, researched the cost effectiveness of computer-based instruction on military personnel, using primarily drill-and-practice software. While this does not deal with teaching children, it does present a view of education. When comparing computer-based instruction with additional tutoring, reduced class size, and increased instruction time, he found that computer-based instruction is cheaper, based on educational outcomes, than any other approach except peer tutoring. In fact, his study shows gains of one-third the training time (Glennan & Melmed, 1995. Unfortunately, the researcher could not find a copy of this study.).

When teachers use technology, it leads to greater student motivation. Research has shown that technology can help students gain initiative in their own learning to go beyond the requirements to learn independently. Once individuals get excited about an assignment, that excitement can rub off on other students as well. This can lead to all students spending more time on task than if there were no computers involved in the project. Likewise, this helps to decrease behavior problems since most, if not all, students are on task (Sandholtz, Ringstaff, & Dwyer, 1997).

When students use their own initiative, they do more than go beyond the requirements of the assignment. They also take the time to learn new applications and skills. This may be something that the teacher never anticipated, but students get excited to learn. They keep working at something till they figure out how to do it right (Sandholtz, Ringstaff, & Dwyer, 1997).

In this era when politicians, businesses, and others are crying for educational reform, technology can help lead the way (Thorpe, 1999; Glennan & Melmed, 1995). Research may indicate that benefits from computer use do not necessarily stem from the computers themselves. Technology can help realign the three ingredients of learning: teachers, students, and content (Thorpe, 1999). If a constructivist approach is taken to teaching and learning, new relationships will form between these three components (Apple Classrooms of Tomorrow, 1995). While more will be said about this later, it is important to note that technology use can be effective, but teachers need to be prepared for technology use to change the way teaching and learning occur in individual classrooms. Teachers who were part of RITTI in Rhode Island were surveyed about how computer use has changed the way they teach. A majority of those surveyed said that they have become more reflective of their own teaching (66%), have changed their role from instructor to coach (52%), and find themselves collaborating with other teachers more frequently (55%) (Thorpe, 1999). It seems to appear that in order to make technology integration effective, teachers need to be willing to change the way they teach.

Not everyone is ready to agree that technology can be effective in our schools. While it is hard to find anyone who is absolutely against computer use in schools, there are a number of moderate voices in the literature surrounding educational technology. One such voice belongs to Larry Cuban.

"This persistent dream of technology driving school and classroom changes has continually foundered in transforming teaching practices," (Cuban, 1996). Cuban makes the point that throughout educational history, "techno-reformers" have been interested in introducing new technologies in schools. Whether it is the laptop computer, public address system, TV and VCR, or any other of a myriad of technological advances, it has been techno-reformers – politicians, business people, and other non-educators – who have pushed for the implementation of these new technologies. Cuban goes on to review why some technologies have been assimilated into the classroom and some have not. Basically, teachers have such a difficult task that they are only willing to implement the things that are quick and easy to implement. Efficiency is the key. Computers take too much time to learn and the hardware can be undependable, so they are put on hold. Cuban argues that had computers been introduced on the teachers' terms, they may be more effective today. According to Cuban, teachers cannot be blamed for this. They are under enough day to day pressures to bother with new technologies. If the pressures can be abated, and if educational technology could be made more efficient, then computers will be used more frequently and effectively in the future (Cuban, 1996).

In another article – "Is Spending Money on Technology Worth It?" – Cuban (2000) looks into the reasons for immersing classrooms with technology. He explains that effective computer use takes more than putting the computers in the classrooms, because most teachers are not computer users. In fact, even many educators who are computer users do not integrate computers into the core curriculum. He continues to explain that there is little hard evidence to prove that today's popular computer applications bring about academic achievement.

One major reason for pouring money into technology is to enable students to be better prepared for the workforce after high school. Cuban suggests that computer skills will not help students be better workers. Technological savvy is not a requirement for many entry-level job opportunities. What is needed is a high school diploma or a college degree, integrity, initiative, and care for the work that is done. So, if educators are interested in helping students get jobs in the future, they need to teach these characteristics. According to Cuban, these qualities cannot always be found through using the obsolete computer hardware and software that can be found in schools. Cuban would rather see money poured into preschool and adult education, reducing class size, and in obtaining well-trained teachers (Cuban, 2000).

Heather Kirkpatrick and Larry Cuban (1998) point out that the technology waves that we see in our schools are based mainly on an assumption that computers will be effective, not on hard evidence. Before spending a lot of money on technology, administrators and teachers should evaluate four questions. What goals will the technology help them reach? Is there a more cost-effective way to attain those goals – even if it does not involve technology? Will the technology help create the kinds of students desired? How can these goals be achieved? For instance, what hardware and software are necessary to attain the goals that were set?

This article also warns that it is not easy to judge the efficiency of technology through the studies that are available. One reason is that educational technology research has lacked a clear focus and a real goal. Researchers have judged efficiency on a number of different criteria: test scores, speed of learning, and motivation. They would like to see a more streamlined set of criteria for judging effectiveness. Second, researchers have ignored a simple question. Are computers cost effective? Research is usually based on a group of computer users against a group of non-computer users. There has never been a study that gauges computer use against other options, like peer tutoring. This would be a better judge of the cost effectiveness of computers. Third, most studies focused on CAI (computer-assisted instruction), not on CEI (computer-enhanced instruction). In CEI, teachers are more instrumental in the learning process than in CAI. According to Kirkpatrick and Cuban, researchers need to tighten up these three components of their studies to make them more reliable than they are now (Kirkpatrick and Cuban, 1998).

Ironically, even though Larry Cuban does not have a lot of good things to say about computer use in schools today, he wrote the forward to *Teaching with Technology*, which is an ACOT book (Sandholtz, Ringstaff, & Dwyer, 1997). In it he writes, "As a long-time skeptic of techno-enthusiast claims about new machines, I found their argument and evidence drawn from a decade's work in classrooms and teacher development sites (1992-1995) most persuasive." Therefore, it seems that Cuban is not against computer use in schools. Instead, it appears that he is crying out for teachers, administrators, parents, and techno-reformers to step back and evaluate why and how computers are being used to see if they can be used more effectively, efficiently, and cost-effectively.

Another moderate voice in the world of educational technology is that of Jane M. Healy (1998). Her book *Failure to Connect: How Computers Affect Our Children's Minds – for Better and Worse* was recommended to the researcher as a controversial book. While there may be some controversial content in the book, Healy comes across as another writer who warns teachers, administrators, and parents to be careful that technology is not being used for the wrong reasons. She says, "While some very exciting and potentially valuable things are happening between children and computers, we are currently spending far too much money with too little thought. It is past time to pause, reflect, and ask some probing questions," (Healy, 1998). She goes on to explain that there has not been enough substantive research to prove that technology use is beneficial to learners of any age. Healy does stress that positive computer use can be found in America's schools, but the negative uses are far more numerous.

The point of computer use, according to Healy (1998), should be to build the brain. That cannot be done effectively through today's "edutainment" programs that claim to educate children with interactive, entertaining activities but spend too much time on entertaining, are not really interactive, and focus on drill-and-practice rather than on critical thinking. She has observed computer use in countless schools and homes across the country, only to find that students can navigate through mazes and buildings with little thought to the educational goals. Random clicking can be just as effective as careful thought with some of the programs that she observed. Teachers and parents should sit with children while they are on computers and occasionally pause to ask them higher level questions about what they are learning through the computer.

One controversial idea that Healy (1998) does have is that children should not be involved with computers before the age of seven. Using an apparent Piagetian philosophy, she claims that using computers can hurt the brain development in a child from birth to age seven. These children need to explore in the real world, using toys and other objects because they are concrete learners. Odd things can happen in the cyberworld that children would not understand and could actually damage their outlook on how the real world really works. For instance, in some software, objects are propelled or pop up on the screen with no logical method for propulsion. This could teach a child that objects can move on their own without help from an outside force. Instead, the child can learn about real movement and force by pushing cars and wooden blocks around the floor.

In all, it appears that Healy wants her readers to judge carefully why computers are being used. An adult should never assume that if a child is sitting in front of a computer, then healthy learning is happening. She does agree that positive computer use can occur, but it is only through careful planning, monitoring, and evaluating of teachers, administrators, and parents that this is possible (Healy, 1998).

In his aforementioned ETS study, Wenglinsky (1998) did not find that computer usage is completely positive. Interestingly, he found that in fourth grade home computer use and school computer use also had a negative relationship to mathematic achievement. In eighth grade, school computer use had a negative relationship to mathematic achievement, but home computer use had a positive relationship with achievement in mathematics. Wenglinsky also noted that home computer use seemed to be promoted by school computer use, making the eighth grade relationship between school use and math scores not as drastic as it would appear on paper. These findings lead Wenglinsky to conclude that the primary focus of computer use should be on middle school students, not elementary students since the eighth graders showed more significant positive effects in mathematic achievement than fourth graders.

The research seems to indicate that educational technology has not met its desired effectiveness for a number of reasons. First, the technology is being used for the wrong purposes. Students are being entertained instead of being educated. Software tends to focus on facts rather than on thought processes (Healy, 1998). Second, policymakers are more interested in filling the classrooms with computers than training teachers to use them effectively (Robelen, 1999). Along with that, techno-reformers are not interested in teachers' concerns about efficiency, only in acquiring hardware (Cuban, 1996). Third, many teachers are not willing to use the technology they have. Obviously, if the computers are not being used, they cannot be used effectively (Wenglinsky, 1998). Fourth, there is not equity in how computers are being used. The purpose of this study is not to discuss the digital divide, but it should be mentioned that it is evident that White, suburban, middle- to upper-class students are using computers for more higher-order thinking activities than minority, urban or rural, lower-class students (Wenglinsky, 1998; Cuban, 1996; Glennan & Melmed, 1995). Until there is equity in computer use, bringing technology to the lower socio-economic schools will not help close the digital divide. Fifth, the nation as an educational community lacks a focus on how to capitalize on the apparent power of technology in the classroom. In order to do this, it is imperative to involve the community and teachers in technology integration and to devote the necessary resources to make sure the integration happens (Glennan & Melmed, 1995). Perhaps, if these problems can be fixed, technology will become a more powerful tool in America's schools.

Research seems to indicate that, if done correctly, computers can be used effectively in the classroom. In order to attain that goal, it is important to look at what effective technology integration is and how it is done in classrooms already. As the research says, if computers are treated as add-ons, they will never be integrated properly into the curriculum (Rein, 2000). Instead, it appears as if they should be treated as tools to make teaching and learning better (Glennan & Melmed, 1995).

ACOT researchers put all teachers on a continuum explaining how they view technology and use it in the classroom. An in-depth look at these stages will be coming later in the chapter. However, the following qualities of technology use can be found in classrooms of teachers who have achieved the highest levels of technology integration. In these classrooms, students can be seen doing different tasks. Technology integration will lead each child down different paths, and a constructivist teacher would be comfortable with allowing students to follow these paths. A variety of student roles will surface based on the students' strengths and abilities. This may mean that a student will assume the role of expert in a particular area of technology use, even being more knowledgeable than the teacher is. Students will collaborate with others. This cooperation could involve fellow classmates, students in other classrooms in the school or far away, or even experts in a particular field, such as a NASA scientist. Work will be presented to the class or others outside the class. This gives a purpose to the task since it will be used to educate others. Technology will be used for tasks that can only be achieved with technology. In other words, in a classroom that has well-integrated technology, the technology will not merely replace other tools like the chalkboard or paper and pencil, but will be used in ways that are only possible because the technology exists. For example, computers make it possible to collaborate with students in another country. According to these findings, many teachers need to be willing to change the way they teach (Rein, 2000). In a study done on teachers in Baltimore, Maryland all participating teachers found that they moved closer to constructivist teaching methods during the course of the study. While not every teacher believed in constructivism, they all took a step closer to it in practice (Fulton & Torney-Purta, 2000).

RAND mentions five uses of computers in education as named by technology advocates: support for individual learning, support for group learning, support for instructional management, communication, and administration (Glennan & Melmed, 1995). If computers can truly be used in all five of these areas, then technology would successfully be integrated into every facet of school life and would make traditional teaching techniques extinct (Wenglinsky, 1998).

As the research states, it appears that technology fits best and most effectively in a constructivist classroom (Aiken & Aditya, 1997). This means that instruction is learner-centered, not curriculum-centered (Ely, 1999). The curriculum should be tailored to individual learners to fit their backgrounds and skills (Aiken & Aditya, 1997). The goal should not be to cover the curriculum, but to make sure that students master the content. This mastery can be achieved through open-ended tasks, rather than by memorizing a predetermined set of facts, and allowing for student-directed learning, allowing students to select tasks and topics that interest them. (Rein, 2000) In this learning-centered instruction, students use their creativity to research and explain things that interest them. When the curriculum is based on problem solving and creative research, students have the opportunity to construct new knowledge and relate it to prior knowledge. Technology opens the door for students to become active learners who interact and think about knowledge rather than having it told to them. Integrating computers into the curriculum gives students another expert source beyond the teacher and the textbook. Computers can help teachers take this step to a problem-solving curriculum which would take students to this level of deeper understanding of information (Apple Classrooms of Tomorrow, 1995).

This type of teaching enables the student to actively pursue knowledge, not just memorize what the teacher says is important. Students are actively involved in their own education, learning not just from the teacher and the textbook, but from other students and experts in the field. (Robelen, 1999)

When students collaborate, whether with classmates or those outside the classroom, they have the opportunity to view knowledge from another point of view that may be more beneficial to them than the teacher's perspective. This has lead to the term "multiple representation of ideas," presenting knowledge in various forms. (Apple Classrooms of Tomorrow, 1995) This is also called multidimensional contact. (Aiken & Aditya, 1997)

Constructivism is not always the best course of action in the classroom. Sometimes direct instruction is required. It is important that the teacher learns how to adequately blend direct instruction and guided inquiry. The ACOT study does not advocate a completely constructivist approach to teaching. Researchers understand that there are times when a collaborative, research-based method is best and there are times when direct instruction will best suit the needs of the students. (Apple Classrooms of Tomorrow, 1995; Ely, 1999; D. DeCamilla, personal communication, January, 20, 2002, 2002)

In the constructivist model, the role of the teacher changes from instructor to guide. According to the ACOT study, students are the masters of the education. (Apple Classrooms of Tomorrow, 1995) This will mean immense changes in the way many teachers teach. (Kleiman, 2000; Wenglinsky, 1998) If technology can be effectively integrated into the curriculum, it would transform the roles of teaching and learning. There would be less lecturing, drill and practice, and rote memorization. Students would be encouraged to explore, and teachers would take on the role of facilitator. (Robelen, 1999)

In this approach, teachers sometimes find themselves as learners too. As students explore various aspects of the world around them, they are bound to learn something that the teacher did not know. So, as students become the classroom experts in various fields, they see that their teacher will learn from them. Teachers can model life-long learning to their students, who will see that learning is something that should never end. (Aiken & Aditya, 1997)

RAND has found that the majority of schools and classrooms do not follow this model. Instead, their research shows that technology integrated classrooms are limited to a handful of teachers who have seen its potential and are excited to try it out. It has not spread well beyond that group. (This is corroborated in Yakel & Lamberski, 2000. Generally, one teacher leads the school. It may be possible for that one person to change the school, but it can be tough to replicate in another building or district.) However, their research led them to five schools that have made great efforts to pioneer universal technology use. In each of these schools, technology has been integrated with instructional standards throughout the school. The students, teachers, and principals have seen new roles emerge as a result of technology integration. Additionally, they have found that technology can help foster communication between the principle participants in education: students, parents, teachers, and administrators. (Glennan & Melmed, 1995)

These schools are different in many ways, from their geographic location in the country, to ethnic groups served, to how they physically built their computers systems, to the grade levels taught. However, when it comes to technology, they seem to have a lot in common. All of these schools put together a strong technology program across the entire school, not just in one or two classrooms. Each school is learner-centered, focusing on the needs of individual students, and they have instituted frameworks to help make each student's goals clear to everyone involved in their education. In order to accommodate technology integration, the daily schedules were manipulated, lengthening periods and integrating subjects together in one period. This was a result of careful planning before the technology arrived. Faculty and staff in these schools began to communicate and collaborate more, changing relationships among adults in the schools. Technology integration has changed the way instruction happens, but it also appears to have improved student learning. While all schools improved on traditional assessments, they also found improvements in other areas such as student and parent engagement, better job placement, support from school families, and attendance. Each school is far above the national average of computer to student ratios with most of the schools having a ratio smaller than 3.9 to 1. Each of the schools spent much more than the national average on technology. Some of the funding came from external sources, creating a link between community and schools (Glennan & Melmed, 1995). These similarities can help model how technology should be integrated into other schools across the nation.

Through integrating technology into the curriculum, these schools found that their instruction was improved. Students felt that their work was authentic and had value. They began to gain the ability to do more complex work, and they were more motivated and had greater self-esteem. Students began to collaborate more, helping each other and their teachers. This enabled teachers to assume the role of coach rather than instructor (Glennan & Melmed, 1995).

South Harrison Community School Corporation in Corydon, Indiana did a technology study in their own district. They made the assumption that it is impossible to isolate technology from other instructional practices. So, they put together a "puzzle" consisting of technology, curriculum aligned with state standards, assessment, classroom management, program evaluation, and instructional strategies. Teachers were encouraged to do more than focus on technology but to implement best practices in all puzzle pieces. The schools that focused on the entire instructional initiative not only saw improved test scores but also enjoyed better attendance and better student attitudes than those who did not embrace the entire puzzle. While it may not be possible to tell if technology was the instrumental factor in this change, it does show that a concentrated effort on improving teaching, including good technology practices, can improve learning (Burnham, Miller, and Ray, 1999).

Something that struck the RAND researchers as being important was that each school and each teacher integrated technology differently. While they all used constructivist principles, they also implemented them in unique ways. RAND researchers warn administrators that technology integration has to be done with teachers at the core of the development process. They point to the ACOT project as a model for this. At every step along the way, the ACOT researchers made teachers and their needs the central focus (Glennan & Melmed, 1995). Larry Cuban (1996) corroborates this idea. He states that techno-reformers have failed at integrating computers into education because they filled classrooms with computers but without teachers' visions in mind.

Looking at all this information, it is hard to say exactly what a technology-integrated curriculum will look like. Pinpointing exact activities that students do can be difficult, since teachers can be found doing many different things. However, it is possible to find some similarities in computer-integrated classrooms. First, they tend to lean toward constructivism. That does not mean that these teachers avoid direct instruction. In fact, the best teachers can deftly blend traditional and constructivist teaching activities. Second, the curriculum is project-based, relying on problem solving and giving students some freedom in the directions of their studies. These real world projects should present the students with the feeling that their work has value. Often, students present these projects to classmates, parents, or others. Third, different students will begin to emerge as experts in different areas, both in technology use and in content areas. In some cases, the expertise may rise above what the teacher can do, creating a great opportunity for the teacher to model lifelong learning. Fourth, there will be a great deal of collaboration among classmates, with students in other schools, with adult experts in various fields, and among faculty and staff. Fifth, the focus is not on technology, but on what can be done with technology (Aiken & Aditya, 1997; Kimble, 1999). In other words, instead of teaching computer skills in isolation, technology integration means teaching those skills as a part of a content area lesson. Sixth, it will be characterized by change. Educational technology brings changes: new approaches to teaching and learning, new accesses to information, new media options, and new communication tools (Ely, 1999).

In 1992, the National Alliance for Restructuring Education aligned with ACOT to help form schools that would transform education. Until then, ACOT researchers were content to observe technology use in education. However, the creation of their Teacher Development Centers launched a new era in ACOT. Since then, ACOT has specialized in training teachers to integrate technology into their curricula and to become constructivist teachers (Sandholtz, Ringstaff, & Dwyer, 1997).

From the beginning of educational technology, the focus was frequently on hardware and software with little emphasis on linking the technology to education. ACOT admittedly made the same mistake. They filled classrooms with wonderful gadgets and software, but they did little to help the teachers learn how to use them effectively in their classrooms (Sandholtz, Ringstaff, & Dwyer, 1997). While schools have spent time and money on reforming their technology, it is important to focus on two other components at the same time: human resources (teachers) and curriculum (Yakel & Lamberski, 2000).

Over the years, ACOT researchers discovered that teachers would begin to use technology to replace something they have already done. For instance, instead of using a worksheet to help a student practice a new skill, they may use a computer program. While this method of technology integration does not use computers to their fullest potential, this is still a necessary step (Sandholtz, Ringstaff, & Dwyer, 1997).

In fact, ACOT researchers have found that there are five steps that teachers go through in the evolution to become technology integrators. These steps are entry, adoption, adaptation, appropriation, and invention. This is a long and arduous process that teachers go through, in many cases taking a couple of school years (Sandholtz, Ringstaff, & Dwyer, 1997).

Researchers have found that the entry stage is when teachers have little or no experience with technology. Some may be afraid of computers, while others are filled with excitement to learn. Regardless, the focus of this stage is not on instruction or integration, but rather on learning how to use the technology itself. Many entry-level teachers felt as if they went back to their first year of teaching, with frustrations over student discipline, management of resources and the classroom, and time-consuming mistakes (Sandholtz, Ringstaff, & Dwyer, 1997).

As teachers begin to learn more about how to use computers, they focus on using them more in the classroom. This is the adoption stage, and it is where most teachers attempt to use technology to blend into what they have always done. In most cases, adoption-stage teachers still use the traditional model and focus more on drill-and-practice, because that is what they know best (Sandholtz, Ringstaff, & Dwyer, 1997).

In the adaptation phase of the growing process, technology is thoroughly integrated into the classroom. However, it is still being used in traditional settings. Lecture, recitation, and seatwork still dominate the school day, although computer use does take up thirty to forty percent of instruction time. Computers tend to be used for such things as CAI, word processors, databases, and graphic programs, showing a more purposeful use of technology. At the adaptation level, teachers begin to see that students are more highly engaged and produce more at a faster rate (Sandholtz, Ringstaff, & Dwyer, 1997).

The appropriation level is a milestone for a teacher to reach. "Appropriation is the point at which an individual comes to understand technology and use it effortlessly as a tool to accomplish real work," (Sandholtz, Ringstaff, & Dwyer, 1997). This is the level where teachers begin to replace traditional teaching habits with new constructivist uses for technology (Sandholtz, Ringstaff, & Dwyer, 1997).

The fifth and final phase of technology integration is the invention stage. At this level, teachers experiment with new instructional practices and new uses for technology. Students are more active in team and problem-based learning activities. This gives teachers an opportunity to observe their students more. Students begin to take on roles of experts in their classrooms and to teach their peers and their teachers in different areas. Teachers also begin to reflect more on their instructional practices and on what happens in their classrooms (Sandholtz, Ringstaff, & Dwyer, 1997).

As more teachers in a school reach the invention stage, the whole school begins to change. It is at this level that teachers begin to collaborate and do activities together whether they are interdisciplinary or multi-grade level activities (Sandholtz, Ringstaff, & Dwyer, 1997).

Professional development is needed to help teachers learn how to use computers effectively and navigate through these stages. However, research shows that staff training still focuses too much on hardware and software and not enough on integration (Sandholtz, Ringstaff, & Dwyer, 1997). If teacher development focuses too much on mastery and not enough on applications, small gains will be made (Aiken & Aditya, 1997). Likewise, current development programs lack the support that teachers need to travel the long hard road called change (Sandholtz, Ringstaff, & Dwyer, 1997).

Teacher development needs a curriculum that is flexible to meet the needs of the teachers who are being trained. Therefore, teachers benefit from a framework that they can implement integration into, not a specific set of guidelines that must be met (Sandholtz, Ringstaff, & Dwyer, 1997).

Training also needs to include observation of teachers and classrooms where technology is being effectively integrated. Teachers need hands-on experience with the computers, including real interaction with real children in real classrooms. They need time to reflect on what they are learning and opportunities to share what they learned with their colleagues. Situated teacher development is when teachers learn through observing and working in real classrooms. Constructivism makes this possible in professional development. Instead of a traditional approach to teacher training, in which the teachers are passive learners, a constructivist curriculum enables teachers to observe and work with teachers and students who are using technology in real school situations (Apple Classrooms of Tomorrow, 1995; Sandholtz, Ringstaff, & Dwyer, 1997).

Theoretically, both adults and children learn better under constructivist practices using more hands-on interactive approaches, not traditional methods such as lecturing. However, most teacher in-services use lecture and do not give teachers the opportunity to practice, interact, reflect, or share. In order to be effective, teacher training needs to model what an actual classroom would look like: meaningful, hands-on, interactive learning. At first, many teachers are not comfortable with the constructivist approach, feeling that a traditional approach would be better. However, while lecture can cover vast material quickly, passive learners get tired of such an approach. With constructivist teaching, teachers get excited to use the computers and experiment with them. Before long, it is evident that trainees receive more quality in their learning than had they learned through lecture, which would merely gain them quantity of information (Sandholtz, Ringstaff, & Dwyer, 1997).

In fact, ACOT trainers train teachers in actual classrooms, where real students are learning (Apple Classrooms of Tomorrow, 1995). In this way, the trainees can interact with students to see what works and can observe teachers in action. This makes the ACOT staff training learner-centered and interactive rather than a series of lectures that must be endured. Situated teacher development gives teachers the ability to learn how computer use can be done effectively in the classroom. This is possible because teachers can observe other teachers actually teaching real children. This gives the trainees new ideas and can affirm practices that are already being done. Situated teacher development can also show a variety of approaches, since the most effective teachers can balance constructivism and direct instruction smoothly. It also provides the trainees with seeing teachers who are at different levels of computer integration (Apple Classrooms of Tomorrow, 1995; Sandholtz, Ringstaff, & Dwyer, 1997).

However, professional development should not be solely about computers. As research has pointed out, technology use is most effective when it is integrated into a constructivist approach to teaching (Sandholtz, Ringstaff, & Dwyer, 1997). After all, many teachers are being asked to change their entire philosophy of education (Ely, 1999).

Technology is merely one tool to reach the students. Therefore, teacher training should also focus on aspects such as interdisciplinary instruction, alternative assessment, project-based learning, and team teaching (Wenglinsky, 1998; Sandholtz, Ringstaff, & Dwyer, 1997). By learning these different aspects of constructivism, teachers will be more apt to adopt the constructivist model as a whole, rather than just technology (Sandholtz, Ringstaff, & Dwyer, 1997). Research indicates that gains in student performance come from changes in teacher practices and school culture, not from technology alone (Thorpe, 1999).

Teachers need time to reflect on what they are learning and doing. This can take the form of journaling or group discussions, but it is important for them to be able to have the time to process new information and skills that they are gaining (Apple Classrooms of Tomorrow, 1995; Sandholtz, Ringstaff, & Dwyer, 1997). However, time is the biggest barrier to technology integration (Robelen, 1999).

When teachers leave the ACOT training centers, they must write a unit plan that they can use shortly after returning to their own schools. This gives them an opportunity to use their new knowledge immediately to reinforce what they learned (Apple Classrooms of Tomorrow, 1995; Sandholtz, Ringstaff, & Dwyer, 1997).

"There is a growing consensus that teacher training and professional development are the weakest but perhaps the most crucial links in the educational technology chain," (Robelen, 1999). Currently, only one third of the nation's K-12 teachers have ten or more hours of technology training, and usually this training is on hardware and software, not on instruction and integration. Most districts are currently spending only fifteen percent or less of their technology budgets on professional development (Sandholtz, Ringstaff, & Dwyer, 1997). However, research shows that schools should be paying up to thirty percent of their technology budgets for professional development (Robelen, 1999). If teacher training continues on like this, it will merely maintain the status quo at best and not foster true change in our schools. New kinds of professional development are necessary to promote technology use to its fullest potential (Sandholtz, Ringstaff, & Dwyer, 1997).

As teachers learn how to use computers and begin to integrate them into their curricula, ACOT researchers found new, emerging patterns of teaching and learning. Not only is there a change in how technology is used, but there are also changes in beliefs about teaching and learning. In fact, according to ACOT, technology integration is less about learning technology and more about getting away from traditional teaching models. In this way, technology becomes a catalyst for change in instructional practices (Sandholtz, Ringstaff, & Dwyer, 1997).

Traditionally, teachers teach the same way they were taught, mainly through lecture, recitation, and seatwork (Sandholtz, Ringstaff, & Dwyer, 1997). However, effective technology integration requires major changes in teaching practices (Kleiman, 2000). It takes time for teachers to change the way they view how things should be done in the classroom, allowing for many successes and recognition from peers and administrators before old habits are replaced with new ones. Over time, teachers can view learning as being more active, creative, and social than ever before. It is important to note that lecture is not always a bad thing. Any form of direct instruction may be appropriate for a particular lesson. Part of the trick of being an effective teacher is knowing when to use direct instruction and when to allow students to construct their own knowledge (Sandholtz, Ringstaff, & Dwyer, 1997).

There is an inner conflict that teachers experience as they begin this process of change. The more change that occurs, the more teachers have to confront their own beliefs and practices. At first, teachers ask how they can use technology to replace what they have always done. After a while, they find themselves asking why they ever taught using the old ways in the first place. This is the kind of questioning and conflict that leads teachers through the stages of technology integration from entry to invention. Conflict leads to questioning, which leads to experimentation and invention. As the classroom changes, students are more engaged in their activities, and teachers and students collaborate, momentum can help move the process along (Sandholtz, Ringstaff, & Dwyer, 1997).

Teachers tend to go through a cycle as they proceed through the first stages of technology use. First, the teacher will initiate some sort of innovation. This will bring about changes in the way things are done in the classroom, some planned and some unplanned. These unintended outcomes will lead the teacher to uncertainty about what is happening in the classroom, which leads the teacher to revert to traditional ways again.

Since students prefer the innovation, they will tend to resist traditional practices. That leads the teacher to dream up a new innovation, which starts the whole cycle over again. Knowing about this cycle and how it works can help teachers deal with frustration when they attempt to integrate technology and change their practices (Sandholtz, Ringstaff, & Dwyer, 1997).

Technology can have an enduring positive impact on students and instruction only if certain conditions are met. First, the teacher needs to realize that a computer is only one tool among many. Teaching cannot be totally computer-bound. Second, computers should be integrated into the curriculum rather than be separated from other content areas in a computer class. Researchers have found that students learn more about technology when it is introduced within regular classes, dealing with content in those classes in meaningful learning activities. This helps students see that the computers have real-life applications (Kleiman, 2000; Aiken & Aditya, 1997; Sandholtz, Ringstaff, & Dwyer, 1997). Third, tool applications (such as word processors, databases, and spreadsheets) are better than drill-and-practice software. These applications are open-ended, and students can explore them without being directed (Sandholtz, Ringstaff, & Dwyer, 1997). It is better for students to be in control of the computer rather than the computer directing the students (Kleiman, 2000). Fourth, teachers need to adjust the technology according to students' strengths and needs. Fifth, teachers have to be willing to change their beliefs about instruction and learning. Technology can be a catalyst for change, forcing educators to reevaluate their educational beliefs (Sandholtz, Ringstaff, & Dwyer, 1997).

Research shows that one of the most vital aspects to teachers becoming technology integrators is support. Teachers who are in the process of changing beliefs, practices, methods, and tools need support from their administration and colleagues. This support can take many forms, but without it, teachers run the risk of never leaving the early stages of computer integration and hanging up their mouse in favor of more traditional teaching practices (Apple Classrooms of Tomorrow, 1995; Sandholtz, Ringstaff, & Dwyer, 1997).

Administrators need to show support for the learning process that the teachers are going through. Teachers need time to learn how to use the new technology and integrate it. This means that they need to be supplied with time to learn, to reflect, to collaborate and to plan with other teachers, and to attend or to speak at conventions and workshops on technology integration. In order for this to work, the teacher's schedule must be altered to give them the blocks of time that are necessary. In addition, it is also important that administrators give recognition for teachers' efforts in this area and take a personal interest in what they are doing by visiting the classroom to see what is happening. This seems like a simple thing, but it means a lot to teachers that their principals are interested in the changes that are taking place. Without backing from the administrator, technology integration may never get off the ground (Sandholtz, Ringstaff, & Dwyer, 1997).

Likewise, it is important that teachers work together for this integration to take place. When there is an atmosphere of change throughout the entire school, it is much easier for teachers to go through the change than if they are trying to do it individually.

This requires that teachers not be isolated from the rest of their co-workers, like traditionally happens throughout America's schools. Instead, there has to be an attitude of cooperation and collaboration across discipline areas and grade levels. Teachers need to take the time to observe their colleagues in their attempts to change and work with them in the planning of technology use (Aiken & Aditya, 1997; Sandholtz, Ringstaff, & Dwyer, 1997). It is important for teachers to network together and with other professionals, seeing each other as valuable resources (Aiken & Aditya, 1997; Thorpe, 1999). Many times this collaboration requires an adventurous leader in the school who is willing to take risks and help his or her colleagues to do the same (Hancock, 1992).

As teachers progress through the stages of technology integration, they also change how they support and help each other. The entry stage requires teachers to show each other emotional support. Since learning how to use computers can be a frustrating thing, new learners need emotional support from their peers sharing struggles as well as successes. As teachers grow into the adoption stage, they still need the emotional support, but they also need added technical assistance. The adaptation stage is where teachers really begin to use computers in their classrooms more frequently. So, in addition to emotional and technical support, they also need assistance in using technology in instruction. This can take the form of sharing ideas together as well as observation of teachers using particular applications in the classroom. As teachers reach the appropriation and invention stages, they add team teaching to the list of supports (Sandholtz, Ringstaff, & Dwyer, 1997).

In schools where teachers are actively evolving toward the invention stage, where principals are supporting this change, and teachers are getting support from their colleagues; team teaching frequently becomes a step in the process. Team teaching can take place across grade levels and/or content areas. It is not always easy for teachers to participate in team teaching, but the benefits are plentiful. Team teaching can increase enthusiasm and support while helping to develop new ideas and methods. It enables teachers to divide responsibilities based on their strengths. Students can benefit from having more grouping options and having more teacher support on an individual basis. In addition, by learning through interdisciplinary instruction, students can see the relationships between content areas, leading to their ability to handle more advanced material (Sandholtz, Ringstaff, & Dwyer, 1997).

The problem is that schools currently do not promote these new innovations. Teachers do not have the time needed to grow in technology integration and constructivism, nor do they have the ability to go and observe their peers on a regular basis. Most teachers in most schools are isolated from their colleagues during the school day. Isolation is one factor that can severely hinder growth in these key areas (Sandholtz, Ringstaff, & Dwyer, 1997). Teachers who can effectively integrate technology tend to come from schools that have high levels of professional development and a technology coordinator who can help lead the way (Wenglinsky, 1998).

Research shows that innovation and collaboration go hand in hand. Without some sort of innovation, such as technology, teachers will not feel a need to collaborate.

Likewise, without collaboration, new innovations would be difficult to mount. Therefore, it is important for technology integration to become effective for administrators and teachers alike to support a school atmosphere that promotes change and cooperation among the teaching staff (Sandholtz, Ringstaff, & Dwyer, 1997).

Therefore, in order for effective technology to form in a school, a number of things have to occur in addition to supplying necessary hardware and software. First, professional development needs to focus on integration. Second, the most effective training is that which is done using a constructivist approach, utilizing observation and hands-on, meaningful activity in real classrooms. Third, administrators and peer teachers must support the efforts of teachers who are training to be technology integrators. Fourth, these teachers must have time to learn, reflect on what they have learned, and share with others. Fifth, it is important that teachers work together as they grow through the stages of technology integration. Sixth, technology integration works best when it is used in a constructivist setting. Keeping these things in mind, schools and teachers can effectively integrate technology so that students can learn in the best possible environment.

The researcher used twenty-two sources in this chapter to discuss the effectiveness of technology use and how teachers can use computers more adequately. Of these sources, eighteen agreed that technology can make a positive impact on education. The remaining four sources were not entirely against computer use in schools, but they did warn that current uses of technology in education need to be reevaluated and that educators must proceed with caution. The researcher is confident that he exhausted the research available to him on the topic of effective technology integration and has presented these sources faithfully while citing the research throughout the review of literature and reference list at the end of this thesis. Chapter three begins with a discussion on the differences between constructivism and traditionalism. The author used an additional eleven sources to present that debate. Six sources were in favor of constructivist teaching, and five sources were in favor of traditional teaching. These sources are also cited in chapter three and in the resources list at the end of the thesis.

CHAPTER III: Procedures and Results

Presentation of the Problem

It is evident from the research that technology integration is most effective when implemented as part of a constructivist approach to teaching. Therefore, this chapter is dedicated to the ongoing debate between constructivism and traditionalism. First, the researcher will present the writings of prominent contemporary constructivists and traditionalists and compare what they have to say to Benjamin Bloom, creator of Bloom's taxonomy. Then, the researcher will present the treatment that he performed on his sixth grade students at Calvary Christian School in Covington, Kentucky, which compared traditional teaching with computer-based constructivist teaching.

Phillip Schlechty (1990), of the Center for Leadership in School Reform, is a constructivist who claims that education's purpose needs to be redirected. The goal of pre-Civil War American education was to promote a common culture based on an Anglo-Saxon Protestant culture. After the Civil War, with the dawn of the Industrial Revolution the focus shifted to selecting and sorting students into various occupational fields. Currently, American education looks to social reform for its purpose. Schlechty's argument is that American education in the twenty-first century needs a new purpose that combines the three purposes mentioned above. American society has shifted from rural, agrarian to urban, industrial and now to global, information-based. It is imperative that twenty-first century schools reform to be geared toward teaching students to function in this society.

The goal of obtaining knowledge should be to apply it to produce a purposeful result. Schlechty calls this "knowledge work." He argues that America's primary mode of work is no longer agriculture or machine-based, but information-based. Therefore, today's students need to learn how to use information in such a way that they can create new innovations in other areas of the economy (Schlechty, 1990).

This will mean a new way of thinking how schools work and reforming how information is transmitted. "For many, *teacher* is synonymous with instructor and conveyor of knowledge. In schools of the future, teachers will not be sources of information; they will be guides to information sources," (Schlechty, 1990). He goes on to say that students will not merely receive knowledge. Instead, they will produce it. In other words, the goal of education should not be to directly instruct students but to teach them how to learn to learn. This will require them to learn how to find information and use that information to solve problems (Schlechty, 1990).

According to Schlechty, the conditions of twenty-first century work will be to work in groups, have self-discipline, loyalty, critical thinking skills, respect the rights of others, and expect to be respected back. Therefore, it is no longer good enough to teach students how to read and do basic math. Basic skills and low-level recall are not sufficient to enable today's students to be tomorrow's workforce. Instead, it is important to teach cooperative learning, problem solving, and thinking skills (Schlechty, 1990).

Howard Gardner, from Harvard University, has developed the theory of multiple intelligences. This theory basically states that there are different intelligences that enable people to learn in different ways. Everyone has all of these intelligences at work in himself or herself, but different people are stronger in different intelligences. Therefore, one student may be strongest in the mathematical/logical intelligence while another student's strength may lie in the musical intelligence. Most schools in America today teach to the mathematical/logical and verbal/linguistic intelligences, but Gardner states that teachers need to take all intelligences into account when teaching (Gardner, 1993).

In his book, *The Unschooled Mind*, Gardner (1991) argues that getting the right answer does not guarantee that a student understands the content. He claims that teaching should be focused on teaching students to apply knowledge in the real world. America's schools would be more successful if they taught students how to think. According to Gardner, students learn best through interactive experiences. In fact, he even promotes a curriculum that involves apprenticeships where students learn a profession through hands-on activity with an actual expert.

Gardner explains that current curriculum does not work for a number of reasons. First, it is removed from society. Without a real-life application to information, the knowledge will not be meaningful. Second, the information is alien to students or it seems pointless to them. Again, if knowledge is related to a real-life application, then students will be more apt to learn it. Third, students do not fully master concepts before they move on to more concepts. The goal of education should be deep understanding.

The best way to do that is through interactive, hands-on learning that integrates content areas (Gardner, 1991).

Benjamin Bloom, in his book *Taxonomy of Educational Objectives, Book One* (1956) seems to agree with these thoughts. He states that knowledge is one of the most common objectives in school, but that each level on his taxonomy should be taught, not just knowledge, without judging one over another. However, he also says that knowledge is of little value if it cannot be used in new situations. He calls this ability to use information "understanding," "really knowing," or "abilities and skills."

Bloom claims that in America's schools, knowledge comes from an external authority or group of experts. While he does not say that this is a bad thing, he does state that knowledge is never definite. "Knowledge is always partial and relative rather than inclusive and fixed." He used the example of the atom, admitting that information about the atom in 1956 was far broader than it was in 1936. He goes on to say that there are "no hard and fast truths which exist for all time and places," (Bloom, 1956).

Since Bloom saw information as a constantly changing commodity, he claimed that knowledge, while important, should not be the sole outcome of education. Students need to be taught how to solve problems and think. He was interested in what students could do with the knowledge that they received. However, problem solving does not happen in a vacuum. Students need knowledge to be able to solve problems. Therefore, it is important for students to learn information and how to use it for critical thinking and problem solving. Bloom calls these "intellectual abilities and skills," (Bloom, 1956).

According to Bloom, America's schools focus on the knowledge level the most because it is the easiest level to impart and to test. However, he was interested in teaching skills along with the information. Due to rapid change and unpredictability of information, there is no way to predict the paths that today's students will experience tomorrow. So, the key is to teach the information that has been most useful in the past and how to use that information to apply to new knowledge (Bloom, 1956).

New knowledge should never be taught in isolation. In order for students to learn and to retain information better, the information should be generalized and related to other information (Bloom, 1956).

In his book, *The Quality School: Managing Students Without Coercion*, William Glasser (1998) tells why students admittedly do not produce quality work. He claims that the problem is that students do not see the work that they are asked to do as being meaningful for them. Instead, they get the message from teachers that low quality is acceptable, so they do not work up to their potential.

Glasser sees schools as being very similar to the workplace. He calls the students workers, and the teachers and administrators are managers. The teachers manage the students, making them mid-level managers, and the administrators manage the teachers, making them upper-level managers. In Glasser's argument, the job of the manager is to help the workers see meaningful purpose in the work that they are asked to do. This will make the work satisfying to the students, thereby making it less boring (Glasser, 1998).

In this book, Glasser contrasts boss-management and lead-management. Boss-management is what drives most schools in America. It can be identified by four factors. The boss sets the tasks and the standards by which they will be judged without consulting the workers. The boss tells, but does not show, the workers how to do the work. The boss inspects the work without involving the workers. If the worker does not do the required work, he or she is coerced into it, making the worker and boss adversaries. In this system, the boss's needs are the focus of the work and mediocrity is often the result (Glasser, 1998).

On the other hand, Glasser also defines lead-management. In lead-management, the worker is consulted about how the work before it is done. The leader models how the work should be accomplished. Workers are respected and asked to evaluate his or her own work. The manager is a facilitator, providing the environment and tools that are required for the workers to do the best possible work. In the lead-management system, it is expected that the manager works in the system (rather than on the system) to make it a better place to work (Glasser, 1998).

In the lead-management that Glasser proposes, teachers work with students to help them produce their best work. Methods such as cooperative learning and problem solving are employed to help each student succeed. The key factors in this system are competency and quality, not time. Therefore, a student does not move on till he or she has proven competency in an area and is producing quality work. Therefore, the effective teacher is one who can convince most, if not all, students to do their very best to produce quality and meaningful work (Glasser, 1998).

E. D. Hirsch, Jr. approaches education from a traditional point of view. His book, *Cultural Literacy: What Every American Needs to Know* (1987), promotes a vast body of knowledge that every American must know in order to be culturally literate. He defines cultural literacy as possessing the basic information needed to thrive in the modern world. This information is not bound to a certain race or socio-economic class, but is necessary for every American to be culturally literate. In fact, he claims that it is only through possession of this knowledge that minorities and disadvantaged children can come out of the poor masses. This is an idea that he writes about in his article, "Why Traditional Education is More Progressive," (1999). In this article, he writes about two politically liberal thinkers from the 1930s who had different educational views. Antonio Gramsci believed that a traditional approach to education would help the poor. On the other hand, Paulo Freire, leaned toward a more constructivist approach to education. According to Hirsch, Freire's philosophies affected the educational system of the United States, but historically, Gramsci's approach has done more for educating the poor.

Hirsch rejects the philosophies of Rousseau and Dewey who claimed that children will develop naturally at a predetermined pace. They said that it is important not to push adult concepts on children until they are ready. Hirsch does not agree with this "content neutral" approach. Instead, he says that only by "piling up specific, communally shared information can children learn to participate in complex cooperative activities with other members of their community," (Hirsch, 1987).

Siegfried Engelmann of the University of Oregon has developed a curriculum entitled Direct Instruction. Englemann believes that every student can succeed if given the correct instruction. If a child does not learn, then the teacher and the school must take responsibility. He claims that a student can be motivated if the teachers will "engineer the behavioral changes that we desire in kids," (Englemann, 1975). In order for teaching to occur, students need to learn. Learning is determined when the student can demonstrate that learning has occurred (Englemann, 1975).

Direct Instruction has teachers in face-to-face contact with students, often in a small ability group. In the course of the day, a teacher is expected to ask over 300 highly scripted questions, which prompt rapid active responses from the students at a rate of ten to fourteen responses a minute. Throughout the lessons there is frequent assessment to be sure that students are learning material. Teachers present examples and non-examples of concepts to communicate to students what a concept is and what it is not. This is contrasted with typical traditional teaching that has one directional communication. In Direct Instruction, teacher and students are constantly communicating. Correct responses get positive reinforcement while incorrect responses are corrected immediately (Parsons & Polson, 2000; Lindsay, 2001).

In Jeff Lindsay's article about Direct Instruction, "What the Data Really Show: Direct Instruction Really Works," he bases the success of Direct Instruction on a study done in the 1970s called Project Follow Through. In this study, Direct Instruction was found to be the best program for building basic skills, cognitive skills, and self-esteem. Lindsay claims that Direct Instruction uncovers the limitations of student-centered learning, which is characterized by a focus on self-esteem, discovery learning, and the teacher as a facilitator. Lindsay, in supporting Englemann's Direct Instruction, rejects the teachings of Jean Piaget, claiming it is "more suited for a naïve communal experiment than for real education," (Lindsay, 2001). Lindsay seems convinced that today's educators should embrace Direct Instruction as the best way to teach students rather than using cooperative learning and teaching students to learn how to learn (Lindsay, 2001).

Therefore, from the writings of Hirsch, Englemann, and Lindsay, it is easy to see that the focus of traditional instruction is imparting knowledge to students. The role of educators is to help students learn specific information to help them function in the society around them and to evaluate whether or not that knowledge has been retained. This dwells on the lowest level of Bloom's taxonomy. However, constructivism, as taught by Schlechty, Gardner, and Glasser, is more concerned with using information, enabling students to be effective workers in tomorrow's economy. The role of educators is to provide meaningful activities using methods such as cooperative learning and problem solving to teach students how to think and learn for themselves. Constructivists are concerned about using all levels of Bloom's taxonomy, especially higher levels that promote higher order thinking.

According to ACOT researchers, professional development should be hands-on and active for teachers. This training should involve teachers working with real students on real educational activities. The author has tried to train himself in such a manner. He has attempted to transform his teaching using more of a constructivist approach. However, the author was also mindful that conversion from a traditional teaching style to constructivism is a growing process involving a number of stages along the way. Therefore, the researcher still held on to some traditional aspects of education.

Presentation of the Hypotheses

In order to determine if students learn better under a traditional teaching model or a constructivist teaching model, the researcher based his experiment on the following null hypothesis.

H_O: There will be no statistically significant difference between the experimental group and the control group when comparing the difference in pretest and posttest scores in math.

The author also desires to know if a constructivist approach to teaching within a math class would motivate students to learn. In order to determine this, the author will use the following null hypothesis.

H_O: There will be no statistically significant difference when comparing students' perceptions of their own motivation toward math class when comparing constructivist and traditional teaching methods.

Subjects

The subjects of this study were all sixth grade students at Calvary Christian School in Covington, Kentucky. There were fifty-one students, separated into two classes. The experimental group had twenty-five students, and the control group had twenty-six students. Each class had a different math instructor, with the researcher teaching the experimental group. Unfortunately, there were less students participating in the second part of the experiment. Due to extended absences due to vacation or illness, only forty-seven students participated in the unit on ratios and proportions. Twenty-three were in the experimental group, and twenty-four were in the control group.

These students were predominately (98%) Caucasian from middle to upper middle-class families. Students were not randomly selected for each class. However, the sixth grade teachers did not have a part in constructing the classes. Classes were put together in an attempt to evenly disperse genders, academic abilities, and behavior problems.

Variables

Independent Variable

The independent variable in this study is style of math instruction. The experimental group was taught using a constructivist approach, making use of a word processor, a spreadsheet, rulers, meter sticks, scales, the Internet, and other materials promoting a hands-on discovery model of teaching. The control group was instructed primarily through traditional methods, focusing more on reading from the text, taking notes, and doing problems from the textbook.

Dependent Variable

The dependent variable in the study was math test scores. Both groups took a pretest before each unit began and a posttest at the close of each unit. These tests were written by Harcourt Brace, the publisher of the book used in class. Differences in the scores of these tests were compared to determine statistical significance.

Procedures

The researcher first sought permission from his principal to perform the study and agreement from his grade-level teaching partner to help in the process. She was asked to do nothing different than what she would usually do. With the blessing of each, the educator wrote a letter that went home to parents (see Appendix A) in a folder that goes home every Friday. The purpose of the letter was to inform parents that their child would be participating in the experiment and that the principal was aware of the experiment. Parents were not given many details, but they were promised details when the whole project was over. To maintain validity, the letter was stapled closed and addressed to parents only so that students would not know that an experiment was happening. Only one parent questioned the researcher about the treatment. She also is an educator and was interested in it from an educator's point of view. During the course of the treatment, some parents questioned the researcher how it was progressing but did not appear to be nervous about their child's education.

Prior to the beginning of the experiment, the researcher spent time online looking for lesson plans that would implement technology and a constructivist approach. Lesson objectives were compared to the book-published objectives to ensure that students would still be prepared for the test at the end of the unit.

Students in both groups were given a pretest at the beginning of a math unit on measurement. This pretest was written by the publisher of the math curriculum used by the school. The test had thirty-two problems on it. The raw scores from both classes were recorded using Microsoft Excel.

Once the pretest was given, the researcher's partner taught math class using the typical methods that she would always use. She demonstrated how to do a particular kind of problem, gave students time to practice, then assigned homework.

The researcher took a different approach to teaching measurement. He took his students to www.AAAmath.com so they could practice metric prefixes and metric lengths. After giving students ample time to do practice, the researcher instructed students on "The Wave," a device developed by his partner to help students convert within the metric system. Students broke up into pairs to work on metric conversions. (See lesson plan in Appendix B.)

Another day, the researcher told each cooperative learning group to select one person to learn something new on the computer and teach it to the rest of the group. As the researcher taught these students the basics of Microsoft Excel, the rest of the class was busy estimating lengths of particular items then measuring them to see the actual lengths. As groups reconvened, they created a spreadsheet with Microsoft Excel which displayed the estimated lengths, the actual lengths, the differences between them, and the average of each column. (See lesson plan in Appendix C.)

At the conclusion of the unit, the publisher-created posttest was given to both classes. The posttest was not identical to the pretest. However, individual test items on the posttest tested the same objectives as were tested on the pretest. It also had thirty-two problems. As in any test, students were not allowed to consult math books, notes, calculators, or neighbors. However, both classes were provided with a list of values in the customary system of measurements (i.e., 1 foot = 12 inches), since they were not required to memorize these numbers. All students' raw scores were recorded on a Microsoft Excel spreadsheet.

The researcher used SPSS for Windows Student Version, Release 6.1.3 to run a one-way analysis of variance (ANOVA) test on the data, using the class that they were in as the independent variable and the differences in their scores as the dependent variable.

The next chapter was on ratios and proportions. Due to the fact that the end of the year was swiftly approaching, along with a multitude of schedule-changing events, the researcher decided to use only the first half of this unit in the treatment. Once again, the publisher-created pretest was given to both classes. This test, due to the decreased quantity of content, contained sixteen problems. The raw scores of all students were entered into a Microsoft Excel spreadsheet.

As in the measurement unit, the control group teacher taught this unit like she always would. She primarily used a traditional approach to teaching the content.

The experimental group was taught using constructivist teaching practices. Unfortunately, the school's only Internet capable computer lab was being used by another class during a large portion of this unit. Therefore, the teacher had to rely more on constructivist lesson plans that did not involve technology during this unit.

The introductory lesson was spent outside. Students were split into five groups. Each group was given time to collect sticks, pebbles, dandelions, and live insects. Once they had their materials, they were given a worksheet to do as a group. This worksheet asked them to make ratios based on the quantity of each item collected. Then, they had to go to other groups to find out how the number of their items compared with other groups. Finally, the students were given a few problems in the textbook to do on ratio to evaluate how well they learned ratios. (See lesson plan in Appendix D.)

Another day, the students were required to bring in advertisement flyers for various items. The students worked in pairs to complete a worksheet. They had to search for items that were sold in groups for one price. For example, one group found a carpet cleaning company that will clean five areas for $99. Then, they had to figure out how much that would cost for one item. The next section of the worksheet had them search for items that were sold singly. Then, they had to tell the unit price for one ounce, one pound, or whatever unit the items were sold in. When they finished the worksheet, the students were given a few problems in the textbook to evaluate how well they had learned unit prices. (See lesson plan in Appendix E.)

Following the completion of this unit, both classes were given a posttest. This posttest was also shortened to sixteen questions but was still written by the publisher of the book. Like the unit on measurement, the pretest and posttest were not identical but evaluated the same material. Students were not given any information like they were in the previous posttest. The students' raw scores were recorded on a Microsoft Excel spreadsheet.

The researcher used SPSS for Windows Student Version, Release 6.1.3 to run a one-way ANOVA test on the data, using the class that they were in as the independent variable and the differences in their scores as the dependent variable.

At the end of the treatment, the researcher gave the experimental group a survey to fill out that determined their motivation. (See Appendix F.) The students turned in the survey without putting their names on it. The researcher used SPSS for Windows Student Version, Release 6.1.3 to run a chi-square test with the students' responses to each of the first four questions on the survey.

When the entire treatment was over, the researcher sent another letter home to parents. This letter summarized the author's research and the results of the treatment. (See Appendix G.)

Results

The first ANOVA test was on the measurement unit. The experimental group had an average difference of 16 points between the pretest and posttest, and the control group's average difference was 14.81. With 49 degrees of freedom within groups and 1 degree of freedom between groups, the critical value of F was 4.035 at an alpha level of .05, but the obtained F-value on this test was only .756. This causes the researcher to accept the null hypothesis. Therefore, there was no significant difference in the change in test scores between the experimental group and the control group.

Table 1

One-Way Analysis of Variance for Differences Between Pretests and Posttests in Measurement Unit

Source	df	SS	MS	F
Between groups	1	18.12	18.12	.76
Within groups	49	1174.04	23.96	
Total	50	1192.16		

Note: F was not significant at α=.05.

The second one-way ANOVA test was on the ratio and proportion unit. The experimental group had an average difference of 5.49 points, and the control group's difference was 7.38. With 45 degrees of freedom within groups and one degree of freedom between groups, the critical value of F was 4.06 at an alpha level of .05, and the F-value on this test was 4.29. This causes the researcher to reject the null hypothesis. However, the significant difference was not in favor of the experimental group, but instead it was the control group that did significantly better.

Table 2

One-Way Analysis of Variance for Differences Between Pretests and Posttests in Ratio and Proportion Unit

Source	df	SS	MS	F
Between groups	1	35.08	35.08	*4.29
Within groups	45	368.24	8.18	
Total	46	403.32		

Note: F was significant at α=.05.

The researcher ran four chi-square tests, one on each of the first four questions on the survey given to the experimental group following the treatment. All twenty-five students responded to these questions.

The first question, "Do you prefer to learn math straight from the book or using computers and hands-on activities?" had eighteen students respond that they would prefer activities. This produced a chi-square of 16.88. With two degrees of freedom and an alpha level of .05, the critical value of chi-square is 5.99. Therefore, the researcher can reject the null hypothesis and safely assume that students prefer to learn by constructivist methods.

The second question, "Do you feel that you learned more from using the book or activities?" had sixteen students responding that they felt that they learned more with activities. This produced a chi-square of 10.64. With two degrees of freedom and an alpha level of .05, the critical value of chi-square is 5.99. Therefore the researcher can reject the null hypothesis and safely assume that students believe that they learn more by constructivist methods.

The third question, "Is math more fun using the book only or incorporating activities?" had twenty students responding that they felt that math was more fun with the activities. This produced a chi-square of 26.01. With two degrees of freedom and an alpha level of .05, the critical value of chi-square is 5.99. Therefore the researcher can reject the null hypothesis and safely assume that students believe that they had more fun while learning by constructivist methods.

The fourth question, "Would you like to see all subjects taught using hands-on activities and computers?" had thirteen students responding, "Yes." This produced a chi-square of 3.99. With two degrees of freedom and an alpha level of .05, the critical value of chi-square is 5.99. Therefore the researcher accepts the null hypothesis, showing that students would not like to have constructivist methods in all classes.

Table 3

Results of Chi-Square Tests

Question	Books	Activities	No Difference	χ^2
Style Preference	3	18	4	*16.88
Learned More	4	16	5	*10.64
More Fun	0	20	5	*26.01
Question	Yes	No	No Preference	χ^2
All subjects with activities	13	6	6	3.92

Note: All numbers with an asterisk were significant at α=.05.

These results cause the researcher to believe that students were better motivated toward math class while it was functioning with a constructivist approach, but students are not interested in that approach being used in all classes.

CHAPTER IV: Summary and Conclusions

The researcher is not discouraged by these results. On the contrary, he is encouraged that the experimental group showed some positive gains, although not significant, in the unit in which the most time was spent. This leads him to think that there would be value in attempting this experiment again in the future.

If the researcher would do this project again, he would do some things differently. First, he would perform the experiment for a longer period of time, perhaps an entire school year. That would enable students and teacher alike to adjust to a new teaching style. Six weeks was not enough time for students to get used to a new style and flourish under it. It would also be of benefit to see which units of study garnered the greater gains or the greater losses in a constructivist setting.

Second, he would have given his partner more explicit instructions. He told her to "continue being the wonderful teacher you are." She was definitely more traditional in her approach to teaching than the researcher, but she was not completely a traditional teacher. For instance, one day she sent her students all over the school measuring different items in the building using meter sticks that they made themselves. That is a constructivist thing to do.

Third, the researcher would have focused on more application software than he did in this experiment. It was mentioned that the researcher comes from a traditional background, meaning that he still sees himself far from the appropriation and invention stages of ACOT's levels of teacher evolution. Because of this, he relied more heavily on drill-and-practice web activities than higher level thinking activities such as Web Quests.

Fourth, this experiment may have seen better results earlier in the school year. April and May are tough months to motivate students to do school work. Had the treatment taken place in the fall or winter, students may have been more willing to do their work to the best of their ability. Also, student attendance may have been better earlier in the year. A number of students took vacations during the second unit of the treatment, causing them to miss large parts of the instruction. Even though these students were not counted in the scores, their absences did make the results less valid.

Fifth, it is interesting to note that the experimental group could not use computers for most of the two weeks of the second unit. Therefore, the experiment did not necessarily measure a computer-based constructivist class but a constructivist class. The researcher is confident that with the addition of computers, things could have been different.

Another interesting fact is that in each unit, the class that saw greater gains – significant or not – was also the class that did more poorly on the pretest. Therefore, it may be appropriate to find a new way to evaluate this experiment that will discover which group learned more without necessarily awarding the class that started lowest. This reminds the researcher of ACOT studies that said that new assessments need to be made to gauge what students are learning.

It is also interesting to note what was not measured in this experiment. For instance, this experiment did not measure what students learned beyond the intended objectives deemed important by the publishers of the textbook. However, it is important to note that the experimental group was exposed to a larger variety of methods. These students were able to use spreadsheets for the first time, to practice weighing items and reading scales, to find the area of a rectangle, to type on a word processor, to work collaboratively, and to relate math to real-life scenarios by using nature and newspaper advertisements.

Another interesting fact is that students in the experimental group were more highly motivated in math class during the treatment than when math was taught using a traditional approach. The chi-square tests show that students felt that they learned more with, had more fun with, and preferred constructivist methods. In addition, when asked at the conclusion of each unit what their favorite part of the unit was, students generally named things like using the computers, the weighing activities, or other hands-on activities. Only one person listed doing problems out of the textbook as a favorite activity. All through the experiment, the researcher heard students comment that they were enjoying math more than usual.

As they enjoyed their lessons, they also were able to see how the mathematics worked. Instead of reading from a page in the textbook the size of a liter, they got to see a liter bottle and feel the mass of it filled with water. Instead of just reading about cross multiplication and doing some sample problems, students had the opportunity to become numerators and denominators and act out cross multiplication. These and other experiences appear to have helped the students in the experimental group to have a deeper knowledge of the content covered during the six weeks of the treatment.

The author was surprised to find that technology integration appears to work more effectively within a constructivist approach to teaching and learning. When he set out to write this thesis, he was hoping to find titles of software and web sites that would help students practice what they were learning in a fun way. Now, he realizes that technology integration needs to be so much more than drill-and-practice. Students need the opportunity to use information at a much higher level of learning than merely practicing skills or reviewing memorized facts.

The author would like to express that he does not believe that constructivism alone will help students to learn everything that they need to know in school. As he reviewed each author cited in Chapter Three, regardless of ideology, he found things that he disagreed with. For instance, Howard Gardner is a staunch evolutionist, but the author believes in creation as told in the first chapter of Genesis in the Bible. Siegfried Englemann believes that the best way to present information is to cover a lot in a little bit of time. The author would rather his students know less facts but be able to apply them in real life than have them know many facts but not fully understand them or have the ability of to apply them.

Instead, the author is more likely to side with ACOT researchers who stated many times that the effective teacher knows when discovery is the best approach and when direct instruction is the best approach. While the author will readily admit that constructivism appears to be the best way to teach students, he is not willing to become a radical constructivist. He desires to sit in the middle of the pendulum and take the best of both worlds to help his students learn using the best possible means for their own good.

In order for effective technology to form in a school, a number of things have to occur in addition to supplying necessary hardware and software. First, professional development needs to focus on integration. Second, the most effective training is that which is done using a constructivist approach, utilizing observation and hands-on, meaningful activity in real classrooms. Third, administrators and peer teachers must support the efforts of teachers who are training to be technology integrators. Fourth, these teachers must have time to learn, reflect on what they have learned, and share with others. Fifth, it is important that teachers work together as they grow through the stages of technology integration. Sixth, technology integration works best when it is used in a constructivist setting. Keeping these things in mind, schools and teachers can effectively integrate technology so that students can learn in the best possible environment.

The author wrote this thesis because he was one of many frustrated teachers who had technology at his fingertips but no training in how to use it effectively. His administration offered training on how to use particular applications, but not how to use it in the classroom. Likewise, in graduate school, he was not given the training to teach using technology, even though he was trained to use certain applications. Since he could not find the training he wanted, he set out to do it himself. Now, he realizes that teaching with technology is so much more than giving students a game to play or allowing students to surf the Internet. Learning how to integrate technology effectively in the classroom is a long process that requires the educator to totally rethink how teaching and learning are accomplished. With that in mind, the author is ready to embark along this road and hopes to bring some colleagues with him.

APPENDIX A

March 15, 2002

Dear Sixth Grade Parents:

Starting Wednesday, March 20, your sixth grade student has the inexpressible, joyful privilege of helping me write my thesis. Well, actually, they are not going to do any writing. I'm just going to experiment on them. There is no need to worry. I promise not to scar them for life or do anything strange and bizarre to them.

Mrs. Ellington's class will see very little change in the way her class is run. The only strange thing is that she will actually give the Pretest before she starts a couple of the units.

My class will notice some changes. We will be using computers in class a lot more frequently and doing some hands-on activities. I will also give the Pretest at the beginning of each unit. I will continue to give the publisher-written tests, just like we have been doing all year long.

This will last for about six weeks, covering the next two units of study. Unfortunately, I cannot give you any extra details now, but I promise to give you all the information you want when everything is over. Mr. Schrenker is aware of what is going on, and he gives his full approval. If you are dying to find out what I'm trying to do and can't wait till the end of the six weeks, please contact me privately, and I'll fill you in on the gory details.

You may have noticed that this note came to you stapled shut. In order to keep things as valid as possible, I need to ask you not to discuss this with your child. I'll tell them all about it when we hit the end, too.

Thank you in advance for your cooperation.

Sincerely,

Mr. Dunlap

APPENDIX B

Objective: The student will be able to convert units of length within the metric system.

Materials: Computer lab with Internet access, "The Wave"

Lesson Outline:

1. Direct students to www.AAAmath.com. Once there, have them click on Measurement then Metric Prefixes I. Give them about ten minutes to play the game provided. Once it looks like they have a handle on this game, allow them to also play Metric Prefixes II.
2. Bring all students together. Have them explain the relationships within the metric system based on their prior experience or the computer game.
3. Have them copy "The Wave" into their math journals. Explain how "The Wave" can be used to know where to move the decimal point when converting within the metric system.
4. Assign page 272 #10-26 even in their math books as an evaluation. Allow students to work in pairs.

"The Wave"

km	hm	dam	m	dm	cm	mm
kilo	hecto	decka	meter	deci	centi	milli
1000	100	10	1	0.1	0.01	0.001

APPENDIX C

Objectives: The student will be able to estimate lengths in the metric system.

The student will be able to subtract to tell how close his or her estimation was to the real length.

The student will be able to build a Microsoft Excel spreadsheet.

Materials: ruler, math book, paper clip, estimation worksheet (see page 74), directions for spreadsheet (see page 75), computer lab with Microsoft Excel.

Lesson Outline:
1. Tell groups to select one person in the group who will learn something new on the computer and then teach it to the rest of the group.
2. Teach the selected students how to use Microsoft Excel, particularly the basics of data entry, sums, differences, and averages. Give students an opportunity to learn some things on their own and get comfortable with it after a quick orientation to the basics.
3. In the meantime, the remaining students should be completing the estimation worksheet (page 74) which has them estimate a number of items in the room then measuring them for a true length.
4. Groups reconvene to create an Excel spreadsheet that has all the required data (page 75). They print it off and a turn it in.
5. Together, the group works on page 275 #10-22 even as an evaluation of estimation.

Group Name:______________________________ Date:________________

MATH
Distance Estimation

You job is to measure various items in the room, but before you measure, you must estimate how big you think the item is. So, first, you estimate, then you measure. Got it? After you have filled in this sheet, I will have further instructions for you.

Your math book: estimate (cm) ________________
actual (cm) ________________
actual (m) ________________
actual (mm) ________________

A pencil: estimate (cm) ________________
actual (cm) ________________
actual (m) ________________
actual (mm) ________________

A paper clip: estimate (cm) ________________
actual (cm) ________________
actual (m) ________________
actual (mm) ________________

A computer keyboard:
estimate (cm) ________________
actual (cm) ________________
actual (m) ________________
actual (mm) ________________

the doorway: estimate (cm) ________________
actual (cm) ________________
actual (m) ________________
actual (mm) ________________

Group Name:______________________________ Date:________________

MATH
Distance Estimation (Part II)

Your next job is to use Microsoft Excel to create a spreadsheet that looks similar to the table below. Use your group's spreadsheet expert to help you learn what to do. However, don't allow him or her to do the whole thing. The expert's job is to teach you how to do it.

	estimated (cm)	actual (cm)	difference
math book			
pencil			
paper clip			
doorway			
average			

APPENDIX D

Objective: The student will be able to write ratios.

Materials: worksheet (see page 75), sticks, pebbles, dandelions, insects

Lesson Outline:

1. Take students outside.
2. Give students between one and two minutes to find each of the following items: sticks, pebbles, dandelions, and live insects.
3. Once they have collected their materials give them the worksheet (page 75) which has them write ratios to compare the quantity of items.
4. When they are done, collect their worksheets. Assign page 305 #7-24 (1st column only) as an evaluation.

Group Name:__________________ Date:___________________ #:__

MATH
Outdoor Ratio Fun

This activity is going to be a group activity. That means that everyone has to work together. Do not allow one or more of your group members let the rest of the group do all the work (or even most of the work). If someone insists on being a hitchhiker (or even a chauffeur) tell me, and we'll work it out.

You group will have 5 minutes to find the following items. You need more than one of each item, but please don't find enough to build a house with.

☺ Sticks (notice, it doesn't say logs or branches)
☺ Pebbles (notice, it doesn't say boulders or rocks)
☺ Dandelions (notice, it doesn't say nice flowers from the flower bed)
☺ Insects (live, preferably)

After you have found these items, please complete the following questions. You may use your math book as a resource. Remember to work together.

1. How many sticks did you get? Pebbles? Dandelions? Insects?

2. What is the ratio of sticks to insects?

3. What is the ratio of pebbles to dandelions?

4. What is the ratio of dandelions to all items you found?

5. What is the ratio of sticks and pebbles to dandelions and insects?

6. Find another group. How many sticks did they find? What is the ratio of your sticks to their sticks?

7. Find out how many pebbles each group found. What is the ratio of your pebbles to 6D's pebbles?

8. What is the ratio of boys in your group to girls in your group?

APPENDIX E

Objectives: The student will be able to determine the unit price of various items.

Materials: advertisements that students provide, worksheet (see page 78)

Lesson Outline:
1. Students break off into pairs.
2. Each pair needs to have advertisement flyers and the unit price worksheet (page 78)
3. Students work together to fill in the worksheet, ultimately finding the unit price of ten items.
4. When each pair finishes and turns in their worksheet, they will work on page 307 #5,8,14, 17, 20, 26, and 27 as an evaluation.

Group Name:__________________ Date:___________________ #:__

MATH
Advertised Unit Prices

This is another group activity. Remember that everyone must work together. No hitchhiking or chauffeuring.

1. Find some ads that advertise selling a group things for a single price (for example, 5 Arby's roast beef sandwiches for $2). Fill in the chart below.

Items	Advertised Prices	Price for One
1.		
2.		
3.		
4.		

2. Find some ads that advertise only one item (for example, a jug of orange juice for $3.49). Fill in the chart below.

Items	Advertised Prices	Number of ounces, pounds, etc.	Price for one ounce, pound, etc.
1.			
2.			
3.			
4.			

APPENDIX F
Math Survey

Circle the answer that best describes how you feel. Then write a sentence or two explaining your answer.

1. Do you prefer to learn math straight from the book or using computers and hands-on activities? Why?

   Book Activities No difference

2. Do you feel that you learned more from using the book or activities? Why?

   Book Activities No difference

3. Is math more fun using the book only or incorporating activities? Why?

   Book Activities No difference

4. Would you like to see all subjects taught using hands-on activities and computers? Why?

   Yes No It doesn't matter.

5. List two things that you liked about math class during the measurement and ratio units.

6. List two things that you did not like about math class during the measurement and ratio units.

APPENDIX G

May 23, 2002

Dear Sixth Grade Family:

My thesis is done! I promised you that when my experiment was over, I would share with you what I was doing, so here it is.

I spent about three months researching how to integrate technology into the curriculum. Without fail, the research claims that the most effective way to do it is within a constructivist approach to teaching. Basically, constructivism teaches students to learn how to think and learn on their own. It takes advantage of cooperative learning and problem solving in order to teach critical thinking skills. In contrast, traditionalism stresses memorizing facts and relies mainly on lecture and textbooks. The research also states that drill and practice and "edutainment" (educational and entertaining at the same time) programs are not as effective as application software, which enables students to take what they have learned and put it into a presentation format.

Anyhow, here's how the experiment ran. I did my best to become a constructivist teacher. Mrs. Ellington continued to teach the way she always has. When each unit was over, I subtracted each student's pretest score from his or her posttest score to determine how much that student learned. Then, I ran some extremely complicated statistical equations (praise the Lord for computers to do it for me) to see if one class did better than the other. On the measurement unit, my class did better than Mrs. Ellington's class. However, in statistics it's not good enough to be better. You have to be significantly better. That means that the gap is so big that there is little doubt that the results were a fluke. We were not significantly better. On the ratio unit, Mrs. Ellington's class was significantly better than my class.

You would think that this would destroy my conclusions, and it was a bit disappointing. However, there were a few reasons why this worked out. We were only able to use the computer lab for one lesson in the second unit. So, it was not a good measure of how well computers helped my students learn. Another thing to realize is that in both units, the class that did better was the one that did worse on the pretest. That means that in a way, we really only measured who knew less going into the unit.

When everything was over, I gave my class a survey to fill out. They significantly agreed that they learned more with, had more fun with, and preferred math class using constructivism rather than tradtionalism. They did not significantly agree that they would like all classes to be like that. These results helped me to say that my students were better motivated in a constructivist setting rather than a traditional setting.

Thank you all for helping with my thesis. If you want to read it, I'd be happy to e-mail you the entire 100 pages.
Sincerely,
Mr. Dunlap

APPENDIX H
GLOSSARY OF TERMS

ACOT: Apple Classrooms of Tomorrow, an experiment turned organization started by Apple, Inc. that helps put technology in schools while training teachers and providing a support network for them.

CAI: Computer-assisted instruction, primarily drill-and-practice software.

CEI: Computer-enhanced instruction.

Center for Leadership Reform: An organization, headed by Phillip Schlechty, that is interested in educational reform by promoting a constructivist approach to teaching.

Constructivism: A teaching model that relies on cooperative learning, problem solving, and higher order thinking. Constructivism is student-centered and aims to make education meaningful in real life situations.

Digital Divide: Typically, White, advantaged, male students have more access to computers and use them for higher-level thinking than their minority, disadvantaged, female counterparts.

Direct Instruction: Traditional curriculum created by Siegfried Englemann of the University of Oregon that shows students examples and non-examples of a particular concept. This should help students get a clear idea of what a concept is and is not. In this model, the teacher asks an average of 300 questions a day.

Edutainment: Educational software that focuses more on entertainment and drill-and-practice than on higher order thinking skills.

ETS: Educational Testing Service. Located in Princeton, New Jersey, they write a number of standardized tests including the Scholastic Aptitude Test (SAT)

Laptop Initiative: The state of Maine and Apple, Inc. partnered to provide every seventh grader in Maine an iBook laptop computer starting in spring 2002.

Link to Learn: Pennsylvania's technology initiative which provided money for local school districts to buy hardware, provide professional development, and network within the community to use the technology at its fullest extent.

Multiple Intelligences: Theory from Howard Gardner from Harvard University that claims that everyone learns and thinks in various intelligences. The ones used the most in American schools are the mathematical/logical and the verbal/linguistic intelligences. Not everyone learns best with these intelligences though.

Situated Teacher Development: Teachers learn through observing and working in real classrooms.

RAND: Research and Development, a non-profit research organization.

RITTI: Rhode Island Teachers and Technology Initiative. Twenty-five percent of Rhode Island's teachers were given a laptop and sixty hours of training on how to use computers in the classroom.

Techno-reformers: People who are not teachers who want to push technology on teachers without consulting teachers on the best way to do it and without the necessary training to use the technology properly.

Traditionalism: A teaching model that relies on lecture, textbooks, rote memorization, and drill and practice. Traditionalism is primarily teacher- or curriculum-centered.

Web Quests: Originally developed at San Diego State University, Web Quests are Internet activities that promote cooperative learning, higher order thinking, and problem solving. http://webquest.sdsu.edu/webquest.html.

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VITA

Craig Dunlap was born November 18, 1970 in Philadelphia, Pennsylvania. His parents, Richard and Eleanor Dunlap, raised him, his older brother Scott and younger sister Cheryl in Richboro, Pennsylvania, a suburb of Philadelphia. He was saved through the ministry of Daily Vacation Bible School at Davisville Baptist Church, when he was five or six, and was baptized when he was eight. While growing up at Davisville, Craig was involved in Boys Brigade and the youth ministry and loved working at a local camp.

Craig graduated from Council Rock High School in 1989 then went on to Philadelphia College of Bible to major in Bible and Education. After graduation, he got his first teaching job as a fourth grade teacher at Phillipsburg Christian Academy in Phillipsburg, New Jersey, where he met his lovely wife Celeste.

Two years later, Craig moved to Northern Kentucky to teach sixth grade at Calvary Christian School in Covington, Kentucky. He has been teaching there for six years. Craig is a member of Calvary Baptist Church where he is involved in the drama program and youth ministry.

Craig Dunlap started his graduate education at Cedarville University in the summer of 2000. He has enjoyed his Cedarville experience, especially the quality of the education he received. Craig has had excellent professors who have made him work hard, but he has learned so much from them.

Craig is planning on using his thesis on educational technology to help him become a better teacher while implementing the wonderful technology that is available to him through his school. In addition to helping his students learn how to use computers better, he is also interested in assisting his colleagues in becoming better technology integrators. He is hoping that he can put his studies to work in his classroom and other rooms throughout his school.

You can contact the author by e-mail at cncd@juno.com.

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