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A comparison of student achievement, self-esteem, and classroom interactions in technology -enriched and traditional elementary classrooms with low socioeconomic students

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A COMPARISON OF STUDENT ACHIEVEMENT, SELF-ESTEEM, AND CLASSROOM INTERACTIONS IN TECHNOLOGY-ENRICHED AND TRADITIONAL ELEMENTARY CLASSROOMS WITH LOW SOCIOECONOMIC STUDENTS

by

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ABSTRACT

The purpose of this study was to compare the attainments of elementary students in technology-enriched classrooms and students in traditional classrooms, while considering performance levels in student achievement, self-esteem, and classroom interactions. Student achievement was measured by the reading and mathematics sections of the *Iowa Tests of Basic Skills* (ITBS) and the *California Achievement Test* (CAT). Composite self-esteem, as well as subscale self-esteem levels, was measured by the Coopersmith Self-Esteem Inventories (CSEI), and classroom interaction analysis measurements were conducted using an adaptation of *Flanders Interaction Analysis System*.

Intact classes from 5 Louisiana elementary schools were randomly assigned to either treatment or control groups in a quasi-experimental design of the time-series type. Treatment classrooms included a variety of technology hardware and software but control classrooms did not. The sample was composed of 211 low socioeconomic students of various backgrounds, races, and ability levels.

Analysis of the achievement and self-esteem data was conducted using univariate analysis of covariance (ANCOVA) procedures and classroom interaction data were examined using chi-square processes. ITBS reading analysis resulted in no significant differences, but CAT reading analyses were statistically significant. ITBS mathematics and CAT mathematics scores were found to be statistically significant. Regarding student self-esteem, the areas of Composite Self-Esteem, School Self-Esteem and General Self Esteem were found to be statistically significant although no statistical significance was found for either Home Self-Esteem or Social Self-Esteem. Classroom Interaction Analyses during the fall and spring of the school year found a significant difference between type of classroom (technology-enriched or not) and type of verbal interactions occurring within those frameworks, with treatment groups being more student-centered and control groups being more teacher-centered.

Results of this study indicated that the presence of classroom technology had a positive effect on the mathematics achievement of the low socioeconomic elementary school students although influence reading achievement remained inconclusive. In addition, classroom technologies appeared to have positive effects on overall self-esteem, general self-esteem, and school self-esteem, and tended to produce more student-directed learning opportunities. School systems should consider the acquisition of additional classroom technologies although further research is needed to replicate these findings.

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LIST OF TERMS

1. Achievement test is defined by Tuckman (1999) as a test "designed to measure the knowledge that an individual has acquired in a number of discreet subject matter areas at one or more discrete grade levels" (p. 210). In the present case, such testing refers to results of the *Iowa Tests of Basic Skills* (Hoover, Hieronymus, Frisbie, & Dunbar, 1996), that consists of a wide-ranging objective and subjective assessment of student development in the basic skills, and to the results of the *California Achievement Test* (CAT/5, 1996).

2. Technology-enriched classrooms are those classrooms that serve as an example of how technology can be innovatively used in education to benefit student learning, as well as those used as test cases in educational research for issues related to educational computing (Beishuizen & Moonen, 1993). In the present case, this refers to five elementary classrooms in Louisiana that consist of technology-trained teachers and the following technological aids: TV/VCR, at least five personal computers with assorted educational software packages, at least one color printer and one laser printer, a scanner, a laserdisc player, a laptop computer, a digital camera, a projection system, and five Internet connections.

3. Traditional classrooms, for the purposes of this study, can be defined as those classrooms that do not include the components listed for technology-enriched classrooms. If computers are present in such classrooms, they are few in number and are used for administrative purposes or entertainment.

4. Standardized self-esteem assessment refers to responses on the Self-Esteem Inventories (SEI) developed by Coopersmith (1989). This 58-item "like-me" or "unlike me" form measures general self-esteem with subscale measurements on social/peer self-esteem (8 items), home/parental self-esteem (8 items), and school/academic self-esteem (8 items). Eight items are also included as lie-scale items on the Inventories to determine if participants answer truthfully.

5. Classroom interactions, a term first used by Flanders (1967), are exchanges of classroom communications between students and teachers that identify data useful for supervisor-teacher conferences, such as the proportion of student talk to teacher talk, types of student responses, types of teacher responses, and initiating or response-type communications among teachers and students (Feirsen, 1984). In the context of the present study, classroom interactions refer to communications in which (a) teachers initiate dialogue and students respond, (b) students initiate dialogue and teachers respond, (c) teachers initiate dialogue and then either respond to that dialogue themselves or continue with unrelated dialogue—before students are permitted to respond, or (d) students initiate dialogue and other students respond.

6. Self-esteem refers to the value a human places on the self. In the present context, this value is measured by the Self-Esteem Inventories (Coopersmith, 1989). An educational claim has been made that if this indicator is high enough, it can result in an individual's increased motivation for group cohesiveness (Schmuck & Schmuck, 1997).

7. Low socioeconomic students refers to those students whose family income, in the least, resides in the lower one-third of all American families, and whom Madaus, Kellaghan, and Schwab (1989) refer to as "findng the schoolwork environment strange

and schoolwork difficult" (p. 80). This study, however, identifies low socioeconomic students as being part of a school in which 70% or more of students qualify for free or reduced lunch programs.

ACKNOWLEDGMENTS

Without doubt, the task of carrying out a dissertation can justly be described as a formidable undertaking. Within that difficult process, there are many whose steadfast support and assistance are seen to be invaluable, and whose encouragement is held in the highest esteem. Therefore, in reflection of the study presented herein, I would like to recognize and offer my most earnest appreciation to those who were so instrumental to the success of this project.

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CHAPTER I

INTRODUCTION

Public resources in the form of funding, hardware acquisition, and training were largely devoted toward classroom technologies during the 1980s and 1990s (Becker, 1998). Many researchers claim that these actions were unjustified and wasteful (Clark, 1994; Holden, 1989; Jegede & Okebukola, 1989 Snowman, 1995); others decry the need for even more of these technologies in schools. Although the advantages of computers in modern society are quite evident, it may be that technology, if only in educational circles, has failed to fully prove itself. Reports on the effectiveness of technology in education have tended to produce conflicting results, and there are many educational technology projects currently enacted that have weak justification for their being (Clark, 1994; Holden, 1989; Jegede & Okebukola, 1989; Krendl, 1986; Kristiansen, 1991; Miller, 1992; Snowman, 1995; Weizenbaum, 1987). Computers and other classroom technologies, nevertheless, have become some of the latest fashions in education. Despite the amount of credible data to support such usage, technologies have entered the educational scene in ever-increasing numbers. More research is needed to examine the effects these tools have on the educational achievement of students worldwide, and more attention should be focused on whether those technologies contribute to the worth each student assigns to himself or herself during the technology-assisted process.

Purpose of the Study

This study investigated the impact of technology on the accomplishments of low socioeconomic elementary students and the sense of worth those students held as a result of that exposure to technology. Thus, the purpose was to compare the attainments of elementary students in technology-enriched elementary classrooms and the attainments of students in traditional (not technologically-enriched) elementary classrooms while considering performances in the following areas: student achievement, self-esteem, and classroom interactions. Participants in the study were from 10 classrooms (5 technology-enriched environments and 5 without such technology) at 5 elementary schools in 5 Louisiana parishes. The technology provided at these schools was, in part, funded by Louisiana Challenge, a recipient of the U.S. Department of Education's Technology Innovation Challenge Grants. This study provides additional data towards the evaluation of that project.

Justification for the Study

Technology has continued to be a driving force in Louisiana (and American) business, commerce, and education. Considering the millions of dollars that have been poured into Louisiana schools for technology purposes, there has been, surprisingly, little research that points definitively toward the benefits of having computers in the typical American classroom (Sabelli & Kelly, 1998). There have been strong indications that computer technology positively affected the academic achievement of some children in some educational environments, but more research was needed to either confirm or reject those findings. In addition, little research has been done to measure the effects that classroom computers have on student self-esteem or student-teacher interactions and how these variables might be related to low socioeconomic students. This study offered additional data as to the value of computers in Louisiana classrooms.

Theoretical Framework

The theoretical framework for this study was based on constructivist perspectives. Vygotsky (1978) was convinced that learning—or internalization, as he called it—was dependant on three transformations: external activity operations being reconstructed to occur internally, interpersonal processes being transformed into intrapersonal processes, and interpersonal processes being transformed into a long series of developmental events.

Vygotsky (1978) held that learning was transitory, that is, meaning undergoes development as it is generalized from one stage of learning to the other, and this gradual internal development results in the maturation of learners as life progresses (Van der Veer & Valsiner, 1994). Learning, achievement, and internalization is constructed throughout the learner's lifespan as learning opportunities present themselves (Barab, Hay, & Duffy, 1998; Jonassen, 1997; Windschitl & Andre, 1998). As Bruner (1997) asserted concerning Vygotsky's views, the mind mediates between individual experiences and external events and builds processes for adding meaning to those experiences.

The process of learning, noted Bruner (1960), is a process whereby early teachings affect later performances due to nonspecific transfers (or constructions) later in life. These transfers of principles and attitudes result from subsequent decisions the individual learner makes (Bruner, 1973; Dewey, 1938) regarding the learning that will or will not take place. Dewey (1944) referred to these future learnings as consequences; these consequences, according to Dewey, must be connected to the changes that precede them for true constructions to take place. According to the constructivist view, young children naturally construct much of their knowledge on their own and from other children—but only if they are allowed to do so by the educational environment in which they exist (Jonassen, Peck, & Wilson, 1999). The theory assumes that humans are created with strong tendencies, or instincts, to learn on their own—albeit with guidance from others (Burton, Moore, & Magliaro, 1996; Dewey, 1939). Constructivism rejects the process whereby processed chunks of knowledge are mechanically transferred from those-in-the-know to those-who-need-to-know and, instead, advocates the making of meaning by those in the process of fulfilling learning objectives. Young children, it is further implied, have a need to work in teams to solve real-world problems in an accountability-derived school setting. As the age of cooperative computing arrives, children would do well to be placed in situations that challenge and encourage their natural drive to solve problems and think critically with computers (Jonassen, Carr, & Yueh, 1998).

Jonassen (1996) proclaimed that computer technology is the tool that best demonstrates constructivism in action. He asserted that students who use computers in education are well placed to express, represent, and organize knowledge constructed through the process of building meaning, what Brownell (1987) referred to as problem-solving. Many educational authorities argue that with the explosion of the information age, learners of the late 20th century are faced with a situation unparalleled in the annals of human history—one in which students must develop problem-solving skills in order to wade through the vast amounts of information available to them (Forcier, 1999; Harris, 1998; Morrison, Lowther, & DeMeulle, 1999; Van Horn, 1991). The amount of available information modern students encounter will quadruple by the time they complete school (Bitter & Pierson, 1999), and this plethora of information can be used by the well-prepared student to construct knowledge to a degree that a classroom teacher would have difficulty imparting (Forcier, 1999).

If the goal of education is to maximize the teacher's efforts and the student's learning, then computer technologies should be integrated into the school curriculum as well as into the school's classrooms, and those tools should be implemented for increased educational efficiency (Newby, Stepich, Lehman, & Russell, 1996). It appears that education has arrived at a point whereby textbooks and teachers are no longer the sole possessors of knowledge, and where the classroom teacher who integrates technology has become the director of the knowledge-access process rather than the all-knowing, not-to-be-disputed educational authority on a pedestal (Duffy & Cunningham, 1996; Heinich, Molenda, Russell, & Smaldino, 1999). Today's educational arena is no longer in a position where time-honored procedures can be relied on to produce similar results in academic achievement.

Computers cannot be expected to achieve high results without human intervention. Educators must make important decisions relating to whether computers will be used, how they will be used, and where they should be used. Simonson and Thompson (1994) argued that the most appropriate place for computers to exist in schools is in individual classrooms. In classrooms, teachers can facilitate and supervise problem-solving activities related to their current studies, and workgroups can be arranged where learning is more likely to be meaningful, intense, and retained. Although classroom computers have as yet failed to prove their potential in most cases, it may be that they have not been utilized in the most advantageous environment—where the training of teachers, the quality of software, and the dedication of school administrators is evident.

Research Questions and Hypotheses

As a result of an in-depth review of literature concerning the outcomes of computer-assisted, computer-based, and other forms of computer-aided classroom instruction, the following research questions and hypotheses were offered:

Research Questions

1. What is the difference in adjusted post-mean scores on a standardized achievement test (*The Iowa Tests of Basic Skills [ITBS]* or the *California Achievement Test [CAT]*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms when using pre-mean scores as the covariate?
2. What is the difference in adjusted post-mean scores on a (composite) standardized self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI]*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms using pre-mean scores as the covariate?
3. What is the difference in adjusted post-mean scores on a general self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], general self-esteem*

subscale) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms using pre-mean scores as the covariate?

4. What is the difference in adjusted post-mean scores on a home self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], home self-esteem subscale*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms using pre-mean scores as the covariate?

5. What is the difference in adjusted post-mean scores on a school self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], school self-esteem subscale*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms using pre-mean scores as the covariate?

6. What is the difference in adjusted post-mean scores on a social self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], social self-esteem subscale*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms using pre-mean scores as the covariate?

7. Is there a difference between type of classroom (technology-enriched or non-technology-enriched) and type of verbal interaction during the fall?

8. Is there a difference between type of classroom (technology-enriched or non-technology-enriched) and type of verbal interaction during the spring?

Research Hypotheses

1. No statistically significant difference exists in the adjusted post-mean achievement test scores (*The Iowa Tests of Basic Skills [ITBS]* or the *California Achievement Test [CAT]*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms when using pre-mean scores as the covariate.

2. No statistically significant difference exists in the adjusted post-mean scores of a composite self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI]*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms using pre-mean scores as the covariate.

3. No statistically significant difference exists in the adjusted post-mean scores of a general self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], general self-esteem subscale*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms using pre-mean scores as the covariate.

4. No statistically significant difference exists in the adjusted post-mean scores of a home self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], home self-esteem subscale*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms using pre-mean scores as the covariate.

5. No statistically significant difference exists in the adjusted post-mean scores of a school self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI],*

school self-esteem subscale) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms using pre-mean scores as the covariate.

6. No statistically significant difference exists in the adjusted post-mean scores of a social self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], social self-esteem subscale*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms using pre-mean scores as the covariate.
7. There will not be a statistically significant difference between the type of classroom (technology-enriched or non-technology-enriched) and the type of verbal interaction during the fall school session.
8. There will not be a statistically significant difference between the type of classroom (technology-enriched or non-technology-enriched) and the type of verbal interaction during the spring school session.

Limitations

1. The random assignment of participants to experimental and control groups was self-reported by school principals and may not have adhered to this study's criteria for selection.

2. The scope of this study was limited to low socioeconomic students living in Louisiana. Generalizations to other groups should be made cautiously.

3. The researcher-developed adaptation of *Flanders Interaction Analysis System* diverts considerably from the initial intentions for the instrument.

4. This study did not attempt to control for specific teaching methodologies, regardless of whether technology-enrichment was present within the classroom. A possibility exists that some teachers used more effective methodologies while others did not.

CHAPTER II

REVIEW OF THE LITERATURE

Because technology tends to move forward at such a rapid rate, the most recent studies were reviewed first, and then the varied situations, grade levels, content areas, and other categories related to learning were examined to produce a compendium of evidence related to the effects of learning with technology. The literature was viewed with an emphasis on modern study, the conflicting reports of technological effectiveness, the skepticism leveled against educational technology research, the early and apparent successes of technology in schools, meta-analytic studies, self-esteem and technology, specific effects in various content areas and on elementary children, cooperative learning and computers, the effects of technology on various nontraditional students, and technology-related classroom interaction analysis.

Mixed Reactions

In the many attempts to describe the effects computers have on young children and their schooling, educational research articles have produced a perplexing combination of reports that leave many questions unanswered. When computers were introduced into public schools—sometime in the early-to-mid 1980s, when those technologies became more affordable—they were seen as the answer to most, if not all, of America's educational ills. Decisions as to how much technology should be involved were hardly questioned. Instead, *equity* in regard to educational computing was a source of dispute. Many educators predicted that there would be an unfair distribution of computer resources to certain wealthy school districts, and measures were begun to curb those outcomes. Those efforts failed, and it appears as if computer inequity continues to plague educational systems nationwide (Milone & Salpeter, 1996; Page, 1998).

Very little time passed before educators realized that the introduction of technology would not live up to earlier expectations (Clark, 1994; Holden, 1989; Jegede & Okebukola, 1989; Kristiansen, 1991; Miller, 1992; Snowman, 1995; Weizenbaum, 1987). Although many research projects proclaimed positive outcomes in regard to computer-aided-student-achievement, many others were inconclusive or negative (Krendl, 1986). Despite the lack of clarity involved with the effectiveness of computer-integrated education, the idea of combining computers and classrooms has been embraced by virtually everyone involved in schooling—from the classroom teacher to the president of the United States.

As the turn of the century approaches, one might argue whether the evidence has become clearer than it once was. Placing computers in classrooms tends to make good sense to administrators, educators, and politicians, who are inclined to assume that such placements will result in positive educational differences. As a result, American educators have poured millions of dollars into computer hardware, software, training, and other associated costs.

Corrupted Research—or Immaturity?

Skeptics have found a voice amid the positive reports on computer-based education. After analyzing more than 800 research articles in 8 major educational technology journals from 1991 to 1996, Jones and Paolucci (1998) concluded that there was very little valid research to support a positive relationship between learning outcomes and computers in the classroom. These researchers also asserted that among those studies reporting positive outcomes, many suffered from unsound research methodologies. During the early 1990s, a gulf appeared between the many advocates of educational technology and the limited research that existed as to the effectiveness of that mode of learning (Hattie, 1991). Although many advocates conceded the fact that research appeared mixed, they also made the assertion that the best methodologies for learning with computers had yet to be developed (Kozma, 1994; Valeri-Gold & Deming, 1991) and that over time, the full benefits of computing in education would be fully realized.

As equity issues in educational technology are resolved, and as more computers are placed into additional American classrooms, the power inherent in computer learning may be all the more evident (Kennett, 1991). This integration should be further enhanced by the increased levels of hypermedia features, which can be expected to give students a much stronger real-world situation in which to work—so strong that it might be difficult for students to distinguish between being at the computer and being on location (Rada, 1999).

During those early eras of technological integration, immaturity may have been behind the discrepancies found between advocacy and empirical reports. Although computer technology-enriched schooling appeared promising in the early 1990s, the whole system of education was subsequently required to change for the ultimate promise to be realized, and the proposed changes would have had to proceed gradually—in incremental steps—if they were to be done correctly (Moonen & Collis, 1992). The computer integration rate in education was, as of the early 1990s, beginning to foster situations whereby students would have their lives directly affected by computer technology (Becker, 1991), and the tendency of educators was to proceed at the most hurried pace.

With great haste many schools obtained high-priced computers in anticipation of instant results. Enjoying little technical support, educators struggled to configure the machines to do tasks that had previously been done manually, and software applications with any claimed educational merit were embraced and purchased for user-friendliness rather than proven quality. In 1986, Parry, Thorkildsen, Biery, and Macfarlane stated that there was growing pressure for educators to use computers in the schools, but there was little guidance as to how that technology might be used. This situation produced Haugland and Shade's (1988) warning to educators that developmental software should reflect sound approaches to education that were already being undertaken or that had been discarded in the past. Nevertheless, as Mandell and Mandell (1989) reported near the end of the 1980s, much of the educational software on the market proved to be unimaginative, poor in quality, and in some cases inaccurate.

Technology for Technology's Sake

Even while holding scarce evidence as to the potential of educational technology, American schools embraced computers from the start. Late in the 1980s, some schools seemed to promote computer learning for the sake of utilizing those tools (Valeri-Gold & Deming, 1991). The technological revolution, when applied to educational circles, created more excitement than anything else in the 1980s. When computers were obtained, however, they were relegated to "learning the computer" processes or for enrichment purposes. It was not until the early part of the 1990s that the monumental effort was brought forth to teach students with the aid of computer assisted instruction (Becker, 1991).

ACOT

Apple's Classroom of Tomorrow (ACOT) project reports appeared to be an exception to the meager reports of the 1980s, as computer-enriched schools were found to result in higher California Achievement Test (CAT) scores and more positive attitudes toward school (Ross, Smith, Morrison, & Erickson, 1989). When Baker, Gearhart, and Herman (1994) later evaluated ACOT's program, they found evidence that positive student attitudes, higher self-esteem, and increased writing abilities were likely due to ACOT implementation. After the first 10 years of ACOT integration, schools reported that the increased access to classroom technologies encouraged more student collaboration, more creative projects, higher student confidence, and more accurate student communicators (Dwyer, 1995). Students with technology-enriched classrooms finally arrived at a point whereby computers could be effectively used as cognitive tools (Jonassen & Reeves, 1996). In a study that explored the effect of technology-rich educational environments on the academic achievement and attitudes of fourth graders, statistical significance was found in favor of technological integration (Grimm, 1995).

Computer-Assisted Instruction: The Catalyst

Computer-Assisted Instruction (CAI) also marked the early days of educational computing. Prior to that time, the classroom teacher was required to conduct all "drilling" activities in a whole-class setting. The introduction of CAI made it possible for individual students (or small groups) to be "drilled" by the computer while the teacher was able to carry out other responsibilities. Thus, students could review mathematics or social studies facts with little or no teacher interaction. This new environment was not only found to be convenient but also productive in many cases. Some of the earliest CAI programs, however, did not show great promise (Clark, 1994; Holden, 1989; Jegede & Okebukola, 1989; Krendl, 1986; Weizenbaum, 1987).

CAI was introduced into American classrooms without definitive data as to its value. Studies of CAI as a reputable tool for any type of learning were scarce. Those that did exist offered inconclusive results when comparing CAI and traditional instruction (Parry, et al., 1986), but soon there arose a number of indications that instruction with the added component of CAI was more effective than using normal instruction alone.

Burns and Bozeman's (1981) meta-analysis of CAI studies involving mathematics became an exception to almost every study conducted during that period. Mathematics-related CAI studies, the authors reported, pointed to a significant increase in mathematics achievement. Clements, Nastasi, and Swaminathan (1993) also indicated evidence of significant computer-aided mathematics achievement for primary age children, and then others did as well (Funkhauser, 1993; Mevarich, Silber, & Fine, 1991; Reglin, 1989; Repman, 1993; Riel & Harasim, 1994; Tyler & Vasu, 1995).

As computers continued to infiltrate American education, subsequent analyses on CAI began to point out the inherent abilities of these tools to help students think, communicate, collaborate, and create (Tinker, 1995). Learners who utilized computer technology in this way—a way that extended beyond the contemporary boundaries of traditional drill and practice computing—found that they could control what the computer did, as opposed to the computer controlling the students. It was discovered that students undergoing lessons involving CAI, when they were examined in the context of learner control preferences, strongly preferred such learner control options (Kinzie, Sullivan, & Berdel, 1992).

CAI research results, although still mixed, eventually indicated positive results in student achievement and student attitudes. Early in the 1990s, a study conducted by Gardner, Simmons, and Simpson (1992) indicated that although most teachers did an inadequate job in evaluating and developing methodologies for science-based CAI (mainly because of the time demands made on teachers who were delegated this responsibility), the combination of hands-on science activities with CAI, with 3rd graders as participants, produced significantly higher levels of knowledge-gain and positive attitudes toward school—particularly science. These activities, according to Gardner, encouraged lifelong learning routines and increased the probability that further learning would take place. He then concluded that other learning environments—especially those with similar CAI structures—could improve lifelong learning habits and lead to more commitment in learning science concepts. Other CAI studies also indicated that positive attitudes toward school were strongly evident among computer-using schoolchildren (Funkhauser, 1993; Kulik, 1986).

Comprehensive Analyses

During the 1980s and 1990s, researchers combined the effects of many studies involving computers and education in an attempt to closely identify the effects involved. These processes, referred to as meta-analyses, involved the collection of *effect* *sizes* of each of the included studies, an intense analysis of these groups as a whole, and then a set of conclusions drawn from those procedures. The effect size is, by far, the most important statistic obtained when research studies are compared and indicates how close (or how far apart, as measured by standard deviation) average students in a treatment group are from average students in a control group (Snowman, 1995).

Christmann, Badgett, and Lucking's (1997) meta-analysis involved 27 studies concerning the academic achievement of 6th through 12th graders who had either received traditional classroom instruction or traditional classroom instruction supplemented with computer-assisted instruction. Each of the studies in the analysis involved achievement in science, reading, music, special education, social studies, mathematics, vocational education, and English. On average, students receiving instruction involving computers attained higher academic achievement than did 58.2% of those in traditional-instruction-only classrooms. In another more-recent meta-analysis involving secondary students in urban, suburban, and rural educational settings, 28 studies examining CAI effects on achievement were analyzed and effect sizes were tabulated (Christmann, Lucking, & Badgett). The CAI students obtained significantly higher achievement scores (an average CAI student scored higher than 56.7% of treatment group students), and, although the effect size was deemed to be low, the indication that computer-assisted instruction was the stronger method produced further evidence of technological utility in education.

In a relatively early meta-analysis of 32 comparative studies measuring computer-based instruction and academic achievement in elementary school children, statistically significant effects were found where CAI was concerned in 28 of the measured cases—with the average effect being an increase in student achievement scores of 0.47 standard deviation, or from the 50th to the 68th percentile (Kulik, Kulik, & Bangert-Drowns, 1985). Subsequently, a late 1980s-early 1990s meta-analysis of 40 studies compared elementary school achievement with the use of microcomputer applications and reported statistically significant effect sizes in relation to academic achievement and technology-based learning (Ryan, 1991). Ryan's analyses also found that in terms of grade equivalents, 3 months additional gain—on average—was found among all treatment groups when compared to control groups, and although the study appeared to add strength to the technology/achievement link, it also indicated that the amount of teacher training was related to achievement levels as well. In the implications of the Ryan study, it was suggested that due to the underreporting of and sample characteristics of the primary research utilized, the potential of an accurate meta-analysis was somewhat limited.

Kulik and Kulik's (1991) meta-analysis of 254 computer-based instruction (CBI) studies also found that student test score differences were positively and statistically significant as a result of that instruction—when compared to control situations not involving such technologies. The average .30 difference in standard deviation between treatment and control groups was an indication that computer-based instruction did appear to produce positive educational effects. Kulik and Kulik, who compiled findings from studies concerning learners of all levels—kindergarten though adulthood—further found what other researchers of their day had been discovering as well: positive student attitudes toward technology, and teaching itself, were significantly more abundant in computer-based classroom environments. Along with

Ryser (1990), Billings and Cobb (1992), and Ehman, Glenn, and White (1992), the Kulik and Kulik study demonstrated that attitude is crucial for the successful use of computer-based environments.

Liao (1992), in another statistical meta-analysis on the achievement-effectiveness of CAI in all grade levels, found that the effect sizes of CAI groups in the 31 studies analyzed were significantly higher when compared to their corresponding control groups. Treatment groups were found to have scored about 18 percentile points higher on the various cognitive-ability evaluations than students who were not given CAI experiences. Liao concluded that the positive effects of CAI extended beyond software content and even the subject being taught. On the contrary, Liao argued that the positive outcomes were a result of the CAI itself.

In another comparison of 32 studies, each of which involved identical writing instruction to classes with or without computerized word processing, Bangert-Drowns (1993) found that in all grade levels, writing improved in the word processing groups, unlike the control group participants involved in the studies. Furthermore, Bangert-Drowns' study showed that among weaker writers, word processing posed an even greater advantage when compared to writing-by-hand methods.

Finally, in a study considered to be the largest and deepest of its kind, a consortium of 5 New York counties spent $14.1 million to collect data on technology effects in the classroom. Although the totality of the results point to the same conclusions—that increasing the technology available to students encourages, facilitates, and supports student achievement—at the elementary level, the most profound effects were found in the area of mathematics, where sixth grade math scores on the state's Comprehensive Assessment Report were strongly related to increases in technological utilization (Mann & Shafer, 1997).

Cooperative Learning and Computers

In educational literature regarding cooperative learning, there are few negative critics. When facilitated thoughtfully, cooperative processes result in quality learning for children even when the make-up of cooperative groups (by gender, ethnicity, socioeconomic status, or ability, for example) is diverse (Yelland, 1995). When computers are used in cooperative groups, they appear to add further advantages to the social dimension of learning. As Berliner (1991) has noted, "Education—even when carried out with personal computers—is an inherently social process" (p. 150).

Because of financial constraints, the process of enriching a classroom with computers still falls short of providing a computer for each individual child. Nevertheless, this goal may be the preferable method of computer distribution. It appears that young children are not only effective in working cooperatively with computers, they prefer to do so (Clements, et al., 1993; Kinzie, et al., 1992) and learn significantly more from each other than if they were to use the computer alone (Mevarich, et al., 1991; Mevarech, Stern, & Levita, 1987; Ryba, Selby, & Nolan, 1995). Interestingly, when examining the cooperative learning literature, it appears unimportant what cooperative groups are studying or whether the groups are structured. Meunier (1994) showed that—as part of the then-renewed debate on whether foreign language instruction and cooperative learning were compatible—an introduction of computer-integrated components had an offsetting effect on the observed drawbacks of conventional communicative activities. Cooperative computer-assisted foreign language instruction was shown to produce greater student achievement, to develop positive attitudes and enhanced levels of intrinsic motivation towards school studies, and to encourage a greater level of activity in foreign language communication.

Much of the research involving cooperative computing focuses on software entitled *Logo*, a graphic-intensive programming language owned by many elementary schools. Attractive to young children because of its intuitive interface, *Logo* has not only been used among elementary students to enhance creativity but also to foster significantly higher levels of motivation, exchanges of information, and conflict resolution (Nastasi & Clements, 1993). The problem-solving ability of 4th grade social studies students has been shown to rise dramatically after *Logo* activities were incorporated into their coursework (Berson, 1996), and student-groups who utilized increased levels of program-provided task-related questioning were seen as experiencing greater success in higher order thinking skills (Berson; Moersch, 1998).

Regarding the additional positive effects cooperative computing appears to have on elementary children, two instances are especially noteworthy. In one study, the creativity among groups of white, middle-class, 3rd grade students was measured in relation to computer-related effects. At the study's conclusion, the assertion was made that on assessments of figural creativity and verbal creativity (but especially in the verbal creativity domain), a significant creative effect was present among the *Logo*-using group members (Clements, 1991). In another experiment, a cooperative computing environment was shown to significantly enhance the higher-level conceptualizations of 5th and 6th grade geometry students (Johnson-Gentile, Clements, & Battista, 1994).

Electronic learning circles—in which students from all areas of the world cooperatively work together on distance learning projects—are good examples of how computers can be networked and utilized to enhance self-esteem and create rich learning environments (Reil, 1990). As the Internet permeates American schools, such projects are clearly underway. These projects are teleapprenticeship in nature and remarkably similar to what Levin, Reil, Miyake, and Cohen (1987) predicted in the mid-1980s—that one of the dominant forms of classroom instruction would involve problem-solving networks on a global scale that tackled problems from various viewpoints (Laffey, Tupper, Musser, & Wedman, 1998).

Using cooperative groups with the structure-filled design of CAI, in most cases, allows children to disagree on a point in their collective research and still successfully continue because of the subsequent computer interaction (Nastasi, Battista, & Clements, 1990). The enhancing effects of such a combination—linkage, structure, openness, capacity, reward, proximity, and synergy—make the approach ideal for special education students (Male, 1988) and significantly increase the subsequent writing abilities of computer partners using writing software (Zellermayer, Salomon, Globerson, & Givon, 1991). Klenow (1992), along with a contingent of students, used computer-animated sequences in a cooperative technique that created numerous memorable learning opportunities for learners worldwide, and Becker's (1992) integrated learning system, utilizing computer technology, was used to facilitate effective cooperative learning activities among children that produced especially impressive results. In addition, student groups using computer-generated interactive video learning laboratories have been shown to be 75% more effective than control-group students (who did not utilize the laboratories) on subsequent posttest questions. Among those students receiving the treatment, 37% less study time, on average, was required to adequately complete evaluative processes than was required of control group students (Switzer & Switzer, 1993).

It also appears as if the problem-solving behaviors of all children, when grouped with same-age peers, are impressive regardless of gender combination. A cooperative group of 7th grade males, on average, is likely to produce similar results when compared to the outcomes of mixed male/female groups when both groups are given the same tasks. In one study, no significant differences where found in the performances of 2nd and 3rd grade students on computer-driven *Logo* activities when cross-gender groups were compared with homogenous groups (Yelland, 1995).

Finally, educating children collectively from long distances, although still in the relatively early stages, has also been made possible by computer technologies. "Electronic field trips" have been available to schoolchildren since the late 1980s (involving Internet connections whereby young students can "visit" the ancient Mayan civilizations, Costa Rica's rainforest, the Florida Everglades, and the National Aeronautics and Space Administration's Observatory, among other areas), and these and similar experiences have provided students with the opportunity to interact and learn from scientists or other groups (Buettner & de Moll, 1996; Levin & Cohen, 1985). Early in the distance learning movement, Levin, Rogers, Waugh, and Smith (1989) found that interactive networks (supplied by Internet gateways) provided children from various global locations with an environment that allowed creative ideas to evolve. Then, Martin and Rainey (1993) found significant gains in posttest achievement scores among high school students that were part of a satellite-delivered high school science course delivered by means of computers and distance learning materials. Although distance learning is in its infancy, it appears apparent that training, technical support, and open communications are crucial to the success of this mode of computer learning (Morrison & Lauzon, 1992).

Overall, collaborative computer-based learning, after proficient student training in the true process of cooperative learning, has been shown to result in statistically significant differences in the achievement of young students. High-level informational exchanges (and increased rates of giving explanations) have also been recorded among treatment group students, and significant increases in self-esteem levels have been reported as well (Repman, 1993). Perhaps most importantly, cooperative learning with computers has been shown to significantly raise the standardized test scores of 6th grade students in the areas of reading comprehension, social studies, study skills, science, and overall reading skills (Secules, Cottom, Bray, & Miller, 1997). Cooperative computing, however, is used far less than drill-and-practice schemes; teachers are more familiar with drill-and-practice computing and, regardless of research to the contrary, they appear to be adhering to what they believe is appropriate computer use (Becker, 1998). Cooperative computing, to be sure, deserves further study and recognition—as well as further attention in the classroom. As Johnson and Johnson (1996) argue in their treatise on cooperation and the use of technology, the failure of schools to utilize cooperative learning in conjunction with computers may be indicative of the computers-gathering-dust dilemma facing many American schools.

Technology Effects on Self-Esteem

Modern American educators have an increased interest in the student's perception of individual worthiness, or self-esteem. Self-esteem was described by Coopersmith (1967) as:

> the evaluation which the individual makes and customarily maintains with regard to himself: it expresses an attitude of approval or disapproval, and indicates the extent to which the individual believes himself to be capable, significant, successful, and worthy. In short, self-esteem is a *personal* judgement of worthiness that is expressed in the attitudes the individual holds toward himself. (pp. 4-5)

Numerous studies have demonstrated that the self-esteem or self-concept of young children has a positive impact on the academic performance of those children. Initially, in a study of 60 randomly selected children by Bruck and Bodwin (1962) in which the Self Concept Scale of the Machover Draw-A-Person Test (SCS-DAP) was utilized, significant evidence was found to indicate that self-concept and achievement were strongly related. Many other studies have resulted in significant levels of correlation between self-esteem and achievement (Beane & Lipka, 1986; Gordon & Brown, 1993; Samuels, 1977; Winne, Woodlands & Wong, 1982).

In the same way, it appears likely that technology use has similar effects on students' self-esteem. Elementary students, overall, have attitudes regarding computers that are quite different from the adult population—preferring to view these new technologies as pragmatic and instrumental (and thus as a means to an end) although adults tend to perceive them in a sociopolitical attitude (Breakwell & Fife-Schaw, 1987). Because students not only tend to prefer computer learning over traditional instruction (Clements, et al., 1993; Kinzie, et al., 1992), and because they appear to perceive of technology as a tool to increase the likelihood of school success (Breakwell & Fife-Schaw, 1987), a logical conclusion can thus be made that computers and self-esteem are complimentary.

A self-esteem study conducted by Ryser (1990) in which computers were introduced into an experimental elementary school while a control elementary school continued with traditional instruction produced significant self-esteem gains by the computer-enriched school. Training given to 7th grade students in computerized collaborative learning has also resulted in significant gains in those students' self-esteem as reported by the Coopersmith Self Esteem Inventories (Repman, 1993). Academic self-esteem among 6th grade students has been measured when those students were involved with computer-assisted learning in small groups, and significant results were reported in regards to math self-concept and math anxiety (Mevarich, et al., 1991).

In an examination of more than 1,000 economics students whereby computer-assisted instruction was utilized for the experimental group but not for a comparable control group, the computer-integrated group scored significantly higher on the Rosenburg Self-esteem Scale (Robertson, Ladewig, Strickland, & Boschung, 1987). Problem-solving simulation software used by an experimental group of 5th grade students also proved to significantly raise students' self-esteem scores although the scores of two other groups—which did not utilize that software—remained constant (Tyler & Vasu, 1995).

Developmental gains of preschool children have been examined when computer software was introduced to that population, and the results show significant positive effects to self-esteem as measured by the Behavioral Academic Self-Esteem (BASE) scale (Haugland, 1992). In addition, introducing computers into both the schools and the homes of children has been shown to significantly raise self-esteem levels (DeGraw, 1990), and a cognitive restructuring experiment on students deemed to be below-average in self-esteem—in which psychologists utilized either (a) computers or (b) relaxation techniques, in an effort to raise student self-esteem levels—produced significantly higher scores for those students involved in the computer-based group (Horan, 1996).

Haugland (1996), citing numerous authorities of educational technology, maintained that for children to have high self-esteem, they must be infused with a sense of belonging—that classroom computers, when utilized properly, can provide. Ironically, Haugland and Shade (1990) had earlier pointed out the independent learning tasks that computers encourage—which also served to benefit the feelings of well-being children experienced. Lee (1990) suggested that there were numerous examples of how technology directly, and positively, affected student self-esteem, and she connected that assertion to correlations between emotional state and academic skills found by psychologists. Computers, especially among children with long histories of failure, have provided experiences whereby low levels of student self-esteem can be enhanced (Ryba, et al., 1995), and technology programs created for pregnant minority students have resulted in significantly raised self-esteem, achievement, and the likelihood of students becoming more active learners (Cocalis, 1995). Interestingly, some studies report that technology usage has little effect on self-esteem. Examinations in self-esteem among secondary students who used word processing instead of the traditional pen-and-paper, for example, have resulted in no significant self-esteem gains (Silver & Repa, 1993).

Self-efficacy, a term similar to self-concept and self-esteem, was described by Olivier and Shapiro (1993) as the perceptions humans have about their own abilities to organize and implement the necessary actions needed to attain skills for specific tasks. Jorde-Bloom (1988) described the term as being concerned with judgements made as to how well organization can take place in the midst of unpredictable, stressful, and ambiguous situations, and concluded that high self-efficacy is an influential factor in the subsequent confidence of task-performance among learners. Because self-esteem and self-efficacy are closely related (a strong argument might be made that the two terms are dependent on each other), and because the literature contains limited evidence regarding the relationship between computer technology and self-esteem, several self-efficacy studies that involve computers are presented here.

In a study focusing on the sensitization of students to classroom technology, it was not only found that the quality—not the quantity—of computer-based instruction was most important, but also that both positive and significant changes in self-efficacy were evident toward e-mail operations among students receiving such quality modes of instruction (Ertmer, Evenbeck, Cennama, & Lehman, 1994). Similar effects have been reported in the software training methods of university management (Gist, Schwoerer, & Rosen, 1989) and among classroom teachers who overcame their technophobia (Hancock, 1990). If technology does have influence on self-efficacy, and if increased self-efficacy beliefs have been shown to increase persistence and improve task performance (Gorrell, 1990), classroom computer assignments would thus be more likely to result in higher-level performances—especially since children tend to take risks to learn new methodologies that peak their interest (Haugland, 1996).

It should be noted here that computer use, even in the educational sense, has often been attacked as causing the dulling of cognitive processes as well as a decline in socialization skills (Miller, 1993; Selnow, 1984, Shotton, 1989, Winkel, Novak, & Hopson, 1987; Zimbardo, 1982). It appears as if the opposite may be true (Colwell, Grady & Rhaiti, 1995). Despite the fact that heavy computer use connotes a less-than-desired level of socialization, significant results have shown that when young boys spend a great deal of time using a computer (even when this use involves playing computer games), those same boys were more likely to see their friends outside of school (Colwell, Grady & Rhaiti, 1995), thus providing what would appear to be increased opportunities for positive or higher levels of self-efficacy or self-esteem.

Computers and Elementary Schools

Much of the experimental evidence regarding computer-based learning has been confined to higher education or to the secondary levels. Because the present examination explores how these technologies impact elementary students, and because there are notable studies that focus primarily on the early-childhood experience with computers, this section presents elementary-specific accounts of those indications.

With few exceptions, most authorities in educational circles agree that to maximize future technology-aided learning, if learning can be significantly affected, computer technology should be provided to children at the earliest opportunity (Haugland & Shade, 1990). When students are introduced to computers at the early-childhood ages, and when level-specific software evaluations are conducted by educators and heeded by those who acquire such programs, subsequent task-related performances tend to rise (Ainsa, 1995). The effectiveness of computer-aided learning in young children might not be so dependent on student learning preferences or the potential expenses that a school incurs (or does not incur) by investing in technology, but by the developmental appropriateness of computer practices and the developmental appropriateness of software used by young children (Haugland & Shade, 1990). Young children exposed to developmentally appropriate software applications (as opposed to children exposed to developmentally inappropriate applications) were significantly more likely to display higher levels of intelligence, structural knowledge, long-term memory, complex manual dexterity processes, self-esteem, and non-verbal skills (Haugland, 1992).

In a study that used computerized picture-word processing to examine kindergarten students' language development, it was concluded that there was a significant, positive difference in the reading development scores of students receiving such instruction when compared to students who had received traditional reading instruction (Chang & Osguthorp, 1990). Evidence has also been presented which underscores the significantly improved level of on-demand mediation present and the improved reading performance among second grade students utilizing CD-ROM storybooks over traditional print books (Miller, Blackstock, & Miller, 1994; see also Matthew, 1997, for similar results among third grade students). In an examination of the effect of computer presentation features on the reading performance of poor-reading 2nd graders, it was found that attained verbal recall levels were significantly comparable to the scores of the students' better reading peers (Calvert, Watson, Brinkley, & Penny, 1990). Success in problem-solving tasks among 3rd and 4th grade students has also been shown to be significant as a result of such presentations (McClurg, 1992).

Unfortunately, although the integration of classroom computers at the elementary level has made great progress in recent years, such integration does not guarantee effective use. As the 1990s began, most computer-using teachers at the elementary level were still using them for enrichment purposes (Becker, 1991). At that point, and in those situations, computer use had not grown to the point where it could significantly affect subject matter competence among students (Becker). A later study reported that computer use at the early elementary level had continued to remain somewhat stagnant; computers, according to the report, were primarily being used with drill-and-practice programs to teach basic skills as opposed to higher order thinking processes (Becker, 1998; Clements, et al., 1993).

Specific Content Effects of Technology

Despite the fact that educational computing research appears mixed, the affects of using computers in education have proved dramatic in several categories. Computer-based pretesting, for example, has resulted in significantly higher performances on subsequent testing—regardless of the tests involved—as well as greater willingness for future learning experiences on the part of students (Dalton & Goodrum, 1991). It has also been found that when students are exposed to computer lessons disguised as computer games, outcomes are positive (Colwell, Grady, & Rhaiti, 1995). Furthermore, significantly greater learning outcomes as well as greater transfer rates of that acquired knowledge have resulted from the use of fantasy-based, problem-solving software (Parker & Lepper, 1992).

In the educational literature, the positive affects of technology have appeared in some areas more than others. One of the areas in which technology has appeared to make great strides is in writing processes. A six-step revising strategy of writing using computerized word processors was found to significantly improve the revising skills of learning-disabled 5th and 6th graders, who also displayed positive changes in final written products (Graham & MacArthur, 1988). Even simple word-processing can make dramatic positive changes in students' attitudes as well as writing abilities (Jankowski, 1998; Lee, 1990).

Although Valeri-Gold and Deming's (1991) research update concerning affects of computer-aided instruction on basic writing found limited support for technology inclusion, there does appear to be evidence that statistically significant writing improvements among nontraditional students have been scientifically observed when such students were taught with some type of computer-assisted instruction (Chavez, 1990; Silver & Repa, 1993; Zellermayer, et al., 1991). As the Internet continues to infiltrate American schools, and as students continue to learn from and teach their peers overseas, the positive effects of computer networks on students' writing skills may be a strong area for study. It has already been shown that such collaboration may produce enhanced writing skills (Riel & Levin, 1990) and that collaborative hypermedia authoring produces higher-quality content when compared to individualized hypermedia writings (Rada & Wang, 1997).

Another content area that appears to be particularly compatible with computer technology is science. In a study that examined the effects of 10th-graders using computer technology to embed cognitive strategies into science software and those who used non-technology means, insect classification tasks were significantly higher in the technology group, and low verbal learners were influenced to a significantly greater extent than were high verbal learners (Barba & Merchant, 1990). Computer simulation approaches, when combined with problem-solving methodologies, produce significantly higher achievement and attitudes in science and chemistry process skills when compared to conventional approaches (Geban, Askar, & Ozkan, 1992). Similar statistically significant outcomes in regard to student science achievement have been reported in biology classrooms and laboratory sessions where simulation software was introduced to the experimental group but not to the control group (Lazarowitz & Huppert, 1993). When students use the Internet in an attempt to understand several core and advanced biology concepts, great enhancements in learning are not only possible but likely to occur (Francis, 1997).

Nontraditional Students and Computers

Although a clear justification for including technology in modern American classrooms is at least arguable, a stronger case might be made for inclusion among special learners. Computers appear to have been especially productive with children designated as nontraditional, and although the term is often used to refer to a variety of non-normal groups of learners, a simple definition of the nontraditional student might be made by referring to those children who have, justifiably or not, been labeled as being low-achieving, at-risk, learning disabled, low socioeconomic status, educationally disadvantaged, language minority, or needing instruction with English as a Second Language (ESL, Burnett, 1981; Wood, Buescher, & Denison, 1979).

As opposed to the more numerous reports wherein regular students have utilized computers with mixed results, the literature contains many cases where special students have experienced increased levels of performance and support when engaging in instruction involving computers. In an exhaustive review of pre-1985 research concerning computer-based instruction, it was found that computers were particularly effective with low-achieving students (Parry, et al., 1986). In addition, it has been shown that learning-disabled students using computers performed logical thinking tasks to a much greater and statistically significant degree in problem-solving activities (Grossen & Carnine, 1990), and students susceptible to failure were found to increase their likelihood for success when utilizing computer technologies (Waxman & Padron, 1995). Student recognition, support, and the enhancement of motivation, self-confidence, and self-esteem among special-needs students (Ryba, et al., 1995) were found to be of such significance that other studies would inevitably follow with additional variables (Schery & O'Connor, 1997; Sheldon, 1996; Zuczek, 1996).

In a study that examined the effects of computer-generated hypermedia cueing on active, neutral, and passive learners, for neutral learners there were statistically significant increases in time on task, frequency of selecting embedded information, and scores on standardized achievement tests. Achievement test improvements were also stated as significant for the passive groups, and the passive group displayed significant performance gains on all dependent variables measured (Lee & Lehman, 1993). Classroom computers were significantly affective among American students whose first-learned language was not English. For Limited English Proficiency (LEP) learners, CAI and computer-assisted testing were affective in speeding up instructional delivery and reducing the amount of time necessary for the development of language proficiency (Dunkel, 1990). In a naturalistic study whereby ESL students participated in a write-to-read program for English language acquisition, there were strong indications that the technological component to the process made considerable differences in student progress (Chavez, 1990). That program was followed by a study in which ESL students significantly improved the quality of writing when word processors were introduced (Silver & Repa, 1993).

The 1970s and 1980s were years in which the dropout epidemic began. Research focused on reasons why increasing numbers of children were not completing the twelve years of schooling normally undertaken by American children, and eventually the term *at-risk* appeared as representing those youngsters who were in danger of dropping out of school (Wood, Bueschel, & Denison, 1979). Classroom computers, it appears, may have had a positive impact on at-risk children. One study reported that Computer Assisted Instruction (CAI) was found to be significantly affective among at-risk urban students in the areas of motivation, self-confidence, and self-discipline—factors that appear to weigh heavily in decisions students make about whether or not to stay in school (Signer, 1991). Another study used computer technology along with a parental involvement component to enhance greatly the at-risk student's probability of staying in school (Poirot & Robinson, 1994). At-risk students who had obviously been alienated from their peers have, after computers were introduced to the learning environment, been consistently observed interacting closely with other students in computer-aided assignments (Diggs, 1997). Exactly why computers appear to influence this alienation-to-interaction phenomenon or why at-risk students tend to respond positively to educational technology is unclear. It may be that classroom computer technology presents the inherent ability of software programs to create problem-solving challenges on which at-risk students tend to thrive (Cantrell, 1993).

Computer technology may also have more significant effects among students classified as low socioeconomic status. One study compared the effectiveness of interactive software on low socioeconomic 1st grade students and found that—among the treatment group—problem-solving was significantly enhanced and that children were more adept at learning to learn (Lehrer & Randle, 1987). Another study found similar results using computer databases with problem-solving techniques (Ehman, Glenn, Johnson, & White, 1992), and yet another found that CAI-integrated courses significantly increased the mathematics achievement scores of first-time college students but that the significance was more pronounced with low socioeconomic students (Reglin, 1989).

In regard to the subsequent impact computers may have on students who are learning-disabled, when low-ability students are paired cooperatively with high-ability students in computerized interactive learning systems, the low-ability students spend longer percentages of time engaged in the learning process (Brush, 1997). Although it might be argued that the ability-grouping process itself could be held accountable for such changes, similar effects in the Brush study occurred among homogeneous groups. It should also be noted that in a naturalistic study on teaching fractions in mathematics—one in which computer-based videodiscs were utilized to present the lessons—learning-disabled students displayed dramatic improvements in learning retention (Woodward & Gersten, 1992). In examining the question of how technology tends to significantly aid slower learners, the key may be what Swan, Guerrero, Mitrani, and Schoener (1990) described in their study of the computer-based instruction effects on educationally disadvantaged students. The authors conclude that the less-threatening environment, along with immediate feedback, individualized diagnostics, and greater academic support, contribute to greater productivity among such populations.

Classroom Interaction Analysis

During the 1960s in America, important questions were addressed concerning the interactions that could be observed in classrooms. Many researchers during that time period believed that if teachers could only learn to control and enhance certain types of interactions occurring in the classroom, more effective and efficient learning could take place (Armstrong, 1979; Kilburn, 1978; Pagliaro, 1979; Popescu, 1978). During that period Flanders (1970), a college professor, developed the *Flanders Interaction Analysis System* (FIAS) to measure initiation/reaction patterns among students and teachers, along with other important interaction data. Received lukewarmly at its debut, the system was subsequently hailed as a revolutionary tool with the potential to vastly affect modern education by improving teaching (Armstrong, 1979; Chadbourne, Bradley, & Ivey, 1981; Cheffers, Mancini, & Martinek, 1980; DeGraw, 1990; Feirson, 1984; Jones & Sherman, 1980; Kilburn, 1978; Ober, 1970; Pagliaro, 1979; Poole & Folger, 1981; Schwanke, 1981; Soar, 1983).

Interaction analysis proved useful in teacher evaluation settings by giving feedback to teachers regarding a number of different observed behaviors (Schwanke, 1981; Sugai & Lewis, 1989). Even in the special education setting, where more individualized instruction typically occurs, interaction analysis was adapted to provide rich data for teacher and supervisor analysis (Feirsen, 1984). The schemes of interaction recorded by the observer entail a powerful technique that encourages systematic observer assumptions prior to the actual collection of data (Poole & Folger, 1981) and that enhances classroom quality by measuring classroom processes in a carefully defined, behavioral manner (Soar, 1983). Most importantly, early in the classroom-interaction-analysis movement it was found that superior achievement could be found among classrooms in which the teacher attained complete compliance from students, but these classrooms also consisted of an environment in which the teacher supported and encouraged student initiative (Flanders, 1967).

Interaction analyses schemes provide a theoretical indication of what has been observed and calculated in a classroom. Using an interaction analysis approach to evaluate classroom behaviors places an educational value on the results and offers the classroom teacher, or in some cases the subsequent reader or researcher, an intelligent opinion as to the significance that process might have for the educational process (Jones & Sherman, 1980). It has been demonstrated that the interaction patterns among various groups is often determined by the level of consensus observed with those groups; higher intergroup interaction, for example, usually results from higher levels of consensus (DeStephen, 1983). When two or more persons interact, the behavior of one always affects the other (Flanders, 1976), whether those affects are subsequently determined to be positive or negative. It appears that educators should closely examine the effects and patterns that various types of classroom interaction have on student learning.

The FIAS and its subsequent adaptations (Amidon & Hunter, 1966; Cheffers, Mancini, & Martinek, 1980; Ober, 1970), unlike the many innovative ideas and solutions in education that fall by the wayside as time progresses, have made a considerable impact on classroom instruction and research (Freiberg, 1981). Software packages such as *Group Interaction Analysis* have been developed to aid the researcher in the gathering of and analysis of interaction behaviors (Cummings, 1986). Although the goal of most users of such systems is to improve the effectiveness of classroom teaching, the results of analyses have focused some attention on allowing students to assume a greater role in the educational process of learning.

In examining such processes from a modern perspective, it appears as though interaction analysis procedures have evolved into a process whereby the teacher can closely examine his or her teaching habits and make effective adjustments to the pedagogical environment. Many contemporary school systems have utilized systematic observation techniques that have subsequently aided in efforts to identify effective teaching in classrooms (Silverman & Buschner, 1990). More importantly, there are strong indications that when interaction analysis leads to constructive criticism and data-supported suggestions for instructional alterations, the effected teachers tend to use those results to change their teaching behaviors (Chadbourne, Bradley, & Ivey, 1981).

In recent years, although an increase in cooperative group work has appeared to be present in American classrooms, the teacher, to a certain degree, has nevertheless been firmly entrenched in the center of that interactional process (Harwood, 1989). In other words, teachers appear to be more the initiators in classroom verbal exchanges than are the students, who are more often the receivers or responders of those communications. As the cooperative learning research attests, however, children appear to learn best from their peers (Berliner, 1993; Clements, et al., 1993; Kinzie, et al., 1992; Mevarich, et al., 1987; Mevarech, et al., 1991; Ryba, et al., 1995; Yelland, 1995). Long ago (Keller, 1968) the need was espoused for teachers to let children learn more on their own, and from other children, in a process that would inherently provide intrinsic and extrinsic motivation. Flanders-based interaction analysis has since become a tool to determine whether students are being allowed to take a participatory role in their own education and to determine how that participation might be affecting learning outcomes.

Technology, although often thought of as being anti-social, may be an important tool in producing student-initiated learning environments. In the mid-1980s, the transition to computer-based learning corresponded with the student-teacher interaction focus. It was then acknowledged that the role of the computer should necessarily be an optional tool although the teacher remained the key to unlocking the needed knowledge (Parry, et al., 1986). Since that time, much has changed. In a study examining the effects of computer technology on classroom interactions, it was found that when classrooms structured with computer-based instruction were compared to traditional classrooms, the technology classrooms were far more likely to produce more student-centered and individualized interactions (Jonassen, Campbell, & Davidson, 1994; Swan & Mitrani, 1993). In addition, it has also been found that interaction with other children is most closely associated with positive student attitudes toward computer technology (McQuarrie, 1989). Cooperative computing appears to create situations whereby students initiate communications more often, either to teachers or other students, and facilitates an environment where the teacher is not central to the richness of learning (Carlson, Ruberg, Johnson, Kraus, & Sowd, 1998; Clements, et al., 1993; Cohen, 1997; Riel, 1989). Furthermore, differing learning styles have been combined in such environments to produce achievement effects far greater than that which occurs when similar learning styles are combined (Reed & Oughton, 1998). Thus, computers may be vehicles that assist in the transformation of traditional classrooms to student-centered classrooms, by allowing for the student's ability to initiate learning situations and build knowledge bases cooperatively with other peers. Whether students desire such initiations is debatable (Saye, 1997), but it appears that such environments facilitate increased learning. If students in technology-infused educational environments substantially benefit by being allowed to initiate classroom dialogue at a greater rate, whether the recipients involve the teacher or other students, then further research is warranted in the areas of student-centered environments, technology pairings within those environments, and the potential benefits of combining the two to produce higher learning rates.

Summary

The idea of having computers in schools was a popular one, regardless of whether sound research methodology could confirm the benefits of such integration. The work done by participants in the Apple Classrooms of Tomorrow (ACOT) projects of the 1980s provided early evidence that technology could affect positive learning experiences. Although subsequent Computer-Assisted Instruction research produced mixed results, schools continued to attain newer and more powerful technologies at increasing rates, even when educational or technical support were unavailable.

Cooperative learning, already proven to a great extent as a method that could produce tremendous learning benefits, was then paired with computer technology to create what appears to be powerful effects. Student self-esteem, the research also suggested, can be positively raised as a result of working within computer environments. Although scant evidence appeared to support a conclusion that computer technology can initiate more student-centered interactions in classrooms utilizing those tools, it may well have been the case that technology-inclusion precipitated student-initiated classroom dialogue.

Children using computers at the early elementary level appeared to benefit in the areas of overall performance on standardized tests, reading, writing, problem solving, and self-esteem. Special students seemed to benefit especially from having computer technology in the classroom. Regarding the mixed results reported in the literature, it might be that planning processes were conducted poorly when the wave of technology maturation began descending on schools in the early 1980s. When it was proclaimed that effective technology-integrated changes could only be brought about with careful planning in schools and that teachers who were unconvinced initially could be won over at later times for increased solidarity (Beishuizen & Moonen, 1993), the assertion might have been a response to the backlash of the technology rush.

Apparently, computer-integrated education must prove itself to justify its costs. Although many have made the claim that the collection of sound evidence concerning computers and school performance was not abundant enough to make inferences as to the inherent value of such combinations, numerous studies have pointed out the apparent advantages to having children learn with computers. To discredit the credibility of that research, it then became necessary to attack the quality of those processes—which many have thus done. More research was necessary to verify or disclaim what has been reported.

CHAPTER III

METHODOLOGY

This chapter outlines the design of the conducted research and the procedures that were utilized to carry out that design. The manner of sample selection is also described, followed by a description of the instruments used in data collection, the procedural details of the study, the potential threats to internal validity, and the results of an initial pilot study. Finally, the statistical methods used in analyzing the collected data are explained, along with the specific probability levels used to reject or accept the null hypotheses.

Research Design

Because whole classes of both experimental and control groups at each of the five sites were examined in regard to the effects of technology on achievement, self-esteem, and interaction patterns, the study utilized a quasi-experimental design described by Campbell and Stanley (1963) as the Time-Series Experiment. According to Campbell and Stanley, the selected design is usually not susceptible to many threats of internal validity, including maturation, testing, instrumentation, regression, selection, mortality, and the interaction of selection and maturation. The authors point out that time-series experiments are vulnerable to another threat to internal validity: history. In general, the longer the time span between measurements of a group, the more likely it becomes that additional events in the participants' environment (other than what the researcher had intended) may influence the results. This study's nine-month time period between measurements would appear to pose such a threat, but the nature of the study required several months to determine if differences in achievement, self-esteem, and classroom interactions would emerge. Furthermore, the random assignment of participants to groups within particular grade levels helped to control for threats of subject selection, maturation, and history.

The independent variable in this study was the use of technology in classrooms, and the dependent variables were student achievement, student self-esteem, and classroom interaction patterns. Student achievement was measured by standardized achievement test data. Self-esteem was determined by the scores from self-esteem assessments, and the factors within student self-esteem (the subscale tabulations of social self-esteem, home self-esteem, academic self-esteem) were also considered in the analysis. Classroom interaction factors consisted of the observed teacher-student communications exchanges, student-teacher exchanges, teacher-teacher exchanges, and student-student exchanges (Flanders, 1970).

Sample

Participants in this quasi-experimental study were 211 students ($\underline{N} = 211$) from 10 classrooms (5 technology-enriched environments and 5 without such technology) at 5 elementary schools in 5 Louisiana parishes. Two of the schools in the study provided 3rd grade classes for the experimental and control groups, while 3 of the schools provided 5th grade classrooms for the experimental and control groups.

Each of the schools utilized in this study qualified for Louisiana Challenge Grant School status. The Louisiana Challenge Grant consisted of a $5.3 million award from a federal Technology Literacy Challenge Fund to help provide technology equipment and high-quality professional development to teachers in Louisiana. Although other factors were considered in the school-designation process, this status was mainly granted because at least 70% of students qualified for federal free-lunch assistance.

Most students served by these schools came from lower-income families and were classified as low socioeconomic students. In addition, each of the classrooms involved in the study was a regular 3rd-grade or 5th-grade class—not a combination class or a special class—and was self-contained with the experimental or control teacher for the major portion of the typical school day. Students in each class were typical of other students in 3rd- and 5th-grade classes at their particular schools (i.e., not gifted or talented), and were reported by their respective principals to have been randomly assigned to either technology-enriched (experimental) or traditional (control) classrooms at the appropriate grade levels at each school.

School A was a south Louisiana pre-kindergarten through 5th grade establishment of 325 students in an urban setting. Among the total students at school A, 75% were black, 20% were white, 4% were Asian, and 1% were Hispanic. School B, also in a south Louisiana urban setting, enrolled 450 kindergarten through 5th grade students of whom 70% were white, 25% were black, and 5% were Hispanic. School C was an urban school in south Louisiana consisting of 940 total students, of whom 90% were black, 8% were white, 1% were Asian, and 1% were Hispanic. School D, the only rural school in this study, was a central Louisiana school of 620 students, 70% of whom were black, 29% of whom were white, and 1% of whom were Asian. School D was also distinguished by the fact that school administrators insisted that student achievement be evaluated by the California Achievement Test (and not the Iowa Test of Basic Skills, as in the cases of the other 4 schools). Finally, school E was an urban school in north Louisiana consisting of 580 total students, 100% of whom were black. Table 1 indicates the number of participants from each school, student race, and student gender.

Table 1: Participant Demographics

		School				
Students	Total	A	B	C	D	E
		Control				
African-American	84	6	11	23	18	26
White	21	6	13	0	2	0
Asian	1	1	0	0	0	0
Female	53	8	9	13	6	17
Male	53	5	15	10	14	9
		Experimental				
African-American	72	8	9	18	12	25
White	27	4	13	4	6	0
Asian	2	2	0	0	0	0
Female	50	7	11	11	8	13
Male	51	7	11	11	10	12

Instrumentation

Student achievement in reading and mathematics was measured in 4 schools by the *Iowa Tests of Basic Skills* (Hoover, Hieronymus, Frisbie, & Dunbar, 1996; ITBS, 1996). One school (School D) administered the *California Achievement Test* (CAT, 1996), because of a local preference for that examination. Reading and mathematics scores were also analyzed from the CAT. With both achievement measures, pretest data were collected from the 1998 administration and posttest data were collected from the 1999 administration. Extensive evaluations of the ITBS have resulted in positive confirmations of test reliability and validity. Drahozal (1997) reported ITBS reliability coefficients of .80 (at the K-3 level) and .87 (at the 3-8 level), while the ITBS Integrated Assessment Program Technical Summary I (IAPT-1) stated validity measures of .92 in 3rd grade reading, .81 in 3rd grade mathematics concepts, .87 in 3rd grade mathematics problem solving, and .83 in 3rd grade mathematics computation. The IAPT-1 also reported validity measures of .92 in 5th grade reading, .87 in 5th grade mathematics concepts and estimation, and .90 in mathematics computation (Integrated Assessment Program Technical Summary I, 1994). Likewise, the CAT has received positive reports in regard to test validity and reliability. The CAT/5 Technical Bulletin 1 (1992) lists reliability levels of .87 for 3rd grade total reading and .84 for total mathematics. In regard to 5th grade reliability statistics, the Technical Bulletin reports levels of .84 for total reading and .87 for total mathematics. McMorris, Liu, and Bringsjord (1998) report .88 validity on the CAT/5 subtest battery, and Nitko (1998) reports .80 to .90 as indicative of CAT/5 validity.

The Coopersmith Self-Esteem Inventories (CSEI) consist of a 58-item form that measures general self-esteem as well as subscale measurements on social self-esteem, peer self-esteem, home (parental) self-esteem, and academic self-esteem (Coopersmith, 1989). The CSEI have also been shown to be valid and reliable in many studies. Bedeian, Teague, & Zmud (1977) reported .81 reliability and .73 validity measures for the CSEI, and Bedeian & Zmud (1977) reported .72 for a validity level. Chiu (1985) also found that 11 out of 24 validity coefficients on the CSEI were statistically significant, and Diaz (1984) found reliable scores on each of the CSEI subscales, as did Drummond, McIntire, and Ryan (1977). Roberson & Miller (1986) provided evidence of construct validity on the CSEI subscales. Although every effort was made in the present study to conceal student names on the self-esteem forms, Nolan, Smith and Stanley (1994) reported no significant differences in CSEI responses among adolescents who knew their names were being reported on the form and those who did not.

Flanders Interaction Analysis Scale (FAIS) consists of a 10-step categorical coding system for classroom observations (see Appendix A). The major feature of the system concerns the analysis of initiative and response—the major characteristic of interaction between individuals. The FAIS devotes seven coding categories to teacher talk: the teacher initiating dialogue through lecture; the teacher initiating dialogue through giving directions; the teacher initiating dialogue by criticizing or justifying authority; the teacher responding to student dialogue by accepting feelings; the teacher responding to student dialogue by praising or encouraging; the teacher responding to student dialogue by accepting or using the ideas of students; and the teacher asking questions of students. The scale devotes two coding categories to student talk—the student responding to dialogue by the teacher and the student initiating dialogue—and one category to silence or confusion.

The observation procedure consists of the observer deciding the category that best represents the communication events heard in the classroom setting, and then tallying these observations alongside the corresponding category. The observer simultaneously assesses continuing classroom communications during the tallying process, thus producing somewhere between 20 to 25 tallies per minute (Flanders, 1970).

This study's adaptation of Flanders' interaction analysis system did not conform simply to recording the *types* of interactions that occur but instead focused on the rates at which teachers or students initiated and responded to verbal classroom communications. Thus, the adaptation of Flanders' scale in the present study resulted in the following scenario:

1. The researcher listened and recorded for 3 minutes, deciding which of the statements observed in the classroom fell in the four predefined groups: (a) teacher-initiated talk with student response; (b) teacher-initiated talk with teacher response; (c) student initiated talk with teacher response; and (d) student initiated talk with student response.

2. The researcher tallied the observed statements in the appropriate quadrant, as they occurred, for each 3 minute time period.

3. For each 3 minute tallying period, the researcher indicated the nature of the learning being observed (e.g., science: teacher-led class discussion regarding the impact that acid rain has on the earth's environment).

4. After each 3 minute period of tallying, a 3 minute rest period was observed, during which the researcher did not record interactions. After 3 minutes, the process was repeated.

There were 3 minute periods when no conversation occurred. In those cases the researcher simply waited until continuous dialogue began, then started the 3 minute tallying period at that point. In the case of group work, the researcher observed onegroup at a time for 3 minutes and recorded in the same way.

To test hypotheses regarding achievement and classroom inclusion of technology, a one-way univariate analysis of covariance (ANCOVA) was utilized to compare the adjusted posttest means of each group (experimental and control) in mathematics and reading. At schools A, B, C, and E, the Reading Total and Mathematics Total sections of the Iowa Tests of Basic Skills (ITBS) were analyzed. At school D the Vocabulary, Comprehension, Mathematical Concepts and Applications, and Analytical Mathematics scores from the California Achievement Test (CAT) were analyzed using ANCOVA.

Likewise, to test hypotheses regarding the various levels of self-esteem and classroom inclusion of technology, ANCOVA was used. The ANCOVA first accounts for variances of pretest means, then variances of posttest means, then finally produces an adjustment to the posttest means to reflect total mean gains. Ferguson (1981) and Crowl (1996) suggest using ANCOVA when there is a need to adjust for the effects of one or more variables that are thus far uncontrolled, making the procedure a logical choice in this case.

Classroom interaction data were totaled for both experimental and control groups and were statistically compared using two chi-square analyses. The analyses consisted of the differences in the four interaction schemes (Student to Student, Student to Teacher, Teacher to Student, and Teacher to Teacher) in the control pretest and posttest and the experimental pretest and posttest. When observed and expected frequencies of observational data must be analyzed nonparametrically, as is the case here, Mason and Bramble (1997) and Witte and Witte (1997) suggested using chi-square analysis.

Reliability of Observation Instrument

Although many communication researchers have made a habit of regarding the coding reliability of observed interactions as irrelevant (Weider-Hatfield & Hatfield, 1984), others hold that the reliability value of any observation tool should be established and reported in the course of any experiment. Therefore, the adaptation of Flanders Interaction Analysis Scale used in the present study was examined in light of the inter-rater reliability to be produced with its utilization. On April 5, 1999, after the researcher conducted a brief training session with an assistant, several hours of dual observation by the researcher and the assistant resulted in the establishment of 74.40 as inter-rater reliability score for the instrument, thereby indicating that the process was reliable. It should be noted that reliability determination was conducted after a request from the researcher's supervisors, and that this process followed the instrument's pilot study. The pilot study of the adaptation of Flanders' Interaction Analysis Instrument was conducted on October 20, 1998, at a northeast Louisiana elementary school. Within a 5th grade classroom consisting of 28 mostly low socioeconomic students, the researcher observed and recorded teacher-student interaction data and subsequently made adjustments to the manner of tabulating communication exchanges (timing adjustments as well as alternative methods for determining recording periods).

Procedural Details

Teachers in both the experimental and control groups were selected by school principals as being their "best" in teaching and communicating with students. The teacher stating an interest in technology—as well as a willingness to undergo technology training—was designated the experimental-group teacher. None of the teachers involved in the study had previous experience in research settings.

Each of the model technology (experimental) classrooms employed a teacher who was fully trained in the use of classroom technologies and who continued to be aware of progressive uses of that technology. Prior to the beginning of the school year, teachers in the experimental classrooms (in addition to Challenge-required training) participated in week-long training institutes at the Louisiana Center for Educational Technology entitled *Teaching, Learning, and Technology Leadership*. During the institutes, instruction centered on integrating technology in the classroom environment and utilizing telecommunications in an effort to allow students to learn from one another. In addition to this training, experimental group teachers also participated in several other training sessions relating to classroom technologies at the state and district levels, which resulted in the accumulation of up to 3 weeks of technology training during the school year (approximately 120 clock-hours of training).

As the year progressed, experimental-group teachers integrated a variety of technology tools and teaching strategies into their curriculum—particularly in science, mathematics, and language arts, and taught students using that technology (or allowed students to use the technology) on a regular basis. Throughout the school year, experimental teachers were supported by Louisiana Challenge staff at the local level. Control group teachers conducted their classroom teaching in the traditional manner. Little or no technology access was provided for control group classrooms, although most contained a computer for teacher use. In the case of School B, however, the control classroom contained five computers awarded from a state grant.

The hardware provided to the experimental classrooms was as follows:

- One teacher computer (which was used by students, and in some cases was a laptop computer)
- Four student computers
- Five Internet connections (including all necessary components, such as wiring, hubs, and network cards)
- One network laser printer (black and white)
- One Inkjet printer (color)
- One large TV monitor
- One presentation device (TV connector or LCD panel with overhead projector or projection system)
- One digital camera
- One Scanner
- One VCR
- One classroom set of calculators
- One laserdisc player with laserdiscs
- One mini-cam computer camera (for videoconferencing)

Software supplied to the experimental classrooms was as follows:

- Integrated office-suite package (Microsoft Word or ClarisWorks)
- Hyperstudio
- Kid Pix
- Multimedia Encyclopedia
- Portfolio Assessment Toolkit (HS Companion)
- Electronic Gradebook
- Other content/grade level appropriate software

Standardized achievement test scores on the *Iowa Tests of Basic Skills* (ITBS) and *California Achievement Test* (CAT) were collected and analyzed. ITBS pretests were administered to all students in April 1998, and posttests administered in March 1999. CAT pretests were administered in September 1998 and postests administered in April 1999.

Each subject also completed the *Coopersmith Self-Esteem Inventories* (CSEI) during each of the two observation sessions during the school year. CSEI pretests were administered in October and November 1998, and posttests administered in April and May 1999. The Inventories were administered, scored, analyzed, and reported by the researcher. In addition, on two separate occasions observational student-teacher interaction data (using the adaptation of *Flanders Interaction Analysis System*) were collected in both experimental and control groups during 1998-1999. The researcher observed and collected interaction data from each of the eight classrooms for an entire school day twice during the school year: once near the beginning of the school year and once near the completion of the school year.

CHAPTER IV

DATA ANALYSIS

This study investigated the influence of classroom technology on the achievement, self-esteem, and classroom interactions among low socioeconomic elementary students. Comparisons were conducted to measure the attainments of elementary students in technology-enriched elementary classrooms and students in traditional (not technologically enriched) elementary classrooms from pretest stages to posttest stages. Standardized achievement test scores on the *Iowa Tests of Basic Skills* (ITBS) and *California Achievement Test* (CAT) were collected and analyzed. As stated in Chapter III, ITBS pretests were administered to all students in April 1998, and posttests administered in March 1999. CAT pretests were administered in September 1998 and posttests administered in April 1999. The Coopersmith Self-Esteem Inventories (CSEI) pretests were administered to students in October and November 1998, and posttests administered in April and May 1999. Observations for the collection of student-teacher interaction data (using the adaptation of Flanders' Interaction Analysis Scale) were conducted in both experimental and control groups on the same date that CSEI measurements were administered.

Hypothesis 1

As stated in Chapter I, null hypothesis 1 read as follows: No statistically significant difference exists in the adjusted post-mean achievement test scores (*The*

Iowa Tests of Basic Skills [ITBS] or the *California Achievement Test [CAT])* of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms, when using pre-mean scores as the covariate. To test this hypothesis, a univariate analysis of covariance (ANCOVA) was utilized to measure the adjusted post means of ITBS and CAT results in total reading, total mathematics, vocabulary, and comprehension.

The Reading Total results of the ITBS are presented in Table 2, and adjusted post-mean determinations are specified in Table 3. The F value of .60 was not statistically significant at the .05 level, thereby indicating no statistically significant difference between the two groups. As Table 3 indicates, control-group participants actually scored higher on the posttest measure. The ITBS Reading Total scores appear to indicate that the two groups scored similarly on that evaluation.

Table 2: One-Way ANCOVA of ITBS Reading Total by Group

Source	df	F
Group	1	.60
Covariate		
ITBS Reading Total Pretest	1	235.65***
S = within group error	106	(103.78)
Total	108	

Note. Values enclosed in parentheses represent mean square error.
***$p < .001$

Table 3: Adjusted Posttest Means of ITBS Reading Total Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	179.19	190.91	190.31	.60
Control	177.81	191.19	191.82	

The Mathematics Total results of the ITBS are presented in Table 4, and adjusted post-mean determinations are shown in Table 5. As can be seen in Tables 4 and 5, a statistically significant difference ($p < .05$) was found between the control and experimental scores of the ITBS Mathematics section. Although the means of each group rose from pretest to posttest, the experimental group's adjusted means were higher when compared to the control group's adjusted means.

Table 4: One-Way ANCOVA of ITBS Mathematics Total Scores by Group

Source	df	F
Group	1	4.69*
Covariate		
ITBS Math Total Pretest	1	193.66***
S = within group error	106	(139.81)
Total	108	

Note. Values enclosed in parentheses represent mean square error.
*$p < .05$. ***$p < .001$

Table 5: Adjusted Posttest Means of ITBS Mathematics Total Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	183.61	197.40	196.42	4.69*
Control	181.22	190.50	191.54	

*$p < .05$

The Vocabulary results of the CAT are presented in Table 6, and adjusted post-mean determinations are specified in Table 7. As Table 6 and Table 7 indicate, a statistically significant difference was found between the adjusted post means of the experimental and control groups ($p < .001$). Table 7 further indicates a 10-point rise between pretest and posttest by the experimental group, while the control group ascended 3 points between tests. The results of the Mathematics Total section of the ITBS appear to favor the experimental group.

Table 6: One-Way ANCOVA of CAT Vocabulary Scores by Group

Source	df	F
Group	1	24.37***
Covariate		
CAT Vocabulary Scores Pretest	1	35.10***
S = within group error	29	(12.94)
Total	31	

Note. Values enclosed in parentheses represent mean square error.
*** $p < .001$

Table 7: Adjusted Posttest Means of CAT Vocabulary Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	11.41	21.53	21.43	24.37***
Control	11.18	15.24	15.34	

***p < .001

. The Comprehension results of the CAT are presented in Table 8, and adjusted post-mean determinations are specified in Table 9. As Tables 8 and 9 indicate, the F value of 23.53 between experimental and control groups suggests a statistically significant difference between mean scores. The experimental group means doubled between the pretest and posttest; although control group scores made marginal gains, the increase demonstrated by experimental group participants was greater.

Table 8: One-Way ANCOVA of CAT Comprehension Scores by Group

Source	df	F
Group	1	23.53***
Covariate		
CAT Comprehension Scores Pretest	1	30.93***
S = within group error	29	(33.24)
Total	31	

Note. Values enclosed in parentheses represent mean square error.
***p < .001

Table 9: Adjusted Posttest Means of CAT Comprehension Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	13.53	27.76	29.19	23.53***
Control	17.71	20.71	19.28	

***$p < .001$

The results of the CAT Mathematical Concepts and Applications section are indicated in Table 10, with adjusted post-mean determinations being specified in Table 11. The F value of 42.03 in Tables 10 and 11 indicates that statistically significant differences were found between the experimental and control groups ($p < .01$), with the experimental group obtaining higher adjusted means.

Table 10: One-Way ANCOVA of CAT Mathematical Concepts and Applications Scores by Group

Source	df	F
Group	1	42.03***
Covariate		
CAT-MCA Pretest	1	14.11**
S = within group error	29	(32.81)
Total	31	

Note. Values enclosed in parentheses represent mean square error.
**$p < .01$. ***$p < .001$

Table 11: Adjusted Posttest Means of CAT Mathematical Concepts and Applications Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	10.35	28.47	26.95	42.03***
Control	7.53	11.65	13.17	

***$p < .001$

Finally, the results of the CAT Analytical Mathematics section are indicated in Table 12, with adjusted post-mean determinations being specified in Table 13. Once again, the difference between the means of experimental and control scores was statistically significant. The means of experimental group participants more than doubled between test administrations (see Table 13) and the resulting F value of 58.86 denoted significance levels favoring the experimental group.

Table 12: One-Way ANCOVA of CAT Analytical Mathematics Scores by Group

Source	df	F
Group	1	58.86***
Covariate		
CAT Analytical Mathematics	1	1.94
Pretest		
S = within group error	29	(42.95)
Total	31	

Note. Values enclosed in parentheses represent mean square error.
***$p < .001$

Table 13: Adjusted Posttest Means of CAT Analytical Mathematics Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	11.00	31.71	31.89	58.86***
Control	12.06	14.71	14.53	

***$p < .001$

The three ANCOVA analyses related to reading—ITBS Reading Total, CAT Vocabulary, and CAT Comprehension—produced mixed results. No significant difference was found between the adjusted post means of the ITBS Reading Total, but significant differences were found on the adjusted post means of the CAT Vocabulary ($p < .001$) and the CAT Comprehension ($p < .001$) tests. Considering that much smaller numbers of students ($N = 31$) were administered the CAT tests than were administered ITBS tests ($N = 108$), it appears difficult to conclude that true differences existed between the experimental and control groups. Therefore, with regard to the mixed results of ANCOVA analysis, the evidence failed to reject the reading component of hypothesis 1.

The three ANCOVA analyses related to mathematics were much more consistent than the reading analyses. Analysis of the ITBS Mathematics Total scores resulted in a statistically significant difference ($p < .05$), and statistically significant differences were found in the CAT Mathematical Concepts and Applications ($p < .001$) analysis and the Analytical Mathematics ($p < .001$) analysis. Considering the evidence that significant differences existed by group in mathematics, the mathematics component of student achievement rejected that portion of hypothesis 1. In summary, no significant differences were found between the two groups in regard to reading although significant differences were found in regard to mathematics.

Hypothesis 2

As stated in Chapter I, hypothesis 2 read as follows: No statistically significant difference exists in the adjusted post-mean scores of a composite self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI]*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms, using pre-mean scores as the covariate. To test the hypothesis, ANCOVA was utilized to measure the adjusted post means of the *Coopersmith Self-Esteem Inventories* (CSEI) composite section. The results of the CSEI composite are indicated in Table 14, with adjusted post-mean determinations in Table 15.

Table 14: One-Way ANCOVA of CSEI Composite Scores by Group

Source	df	F
Group	1	6.57*
Covariate		
CSEI Composite Pretest	1	122.53***
S = within group error	163	(126.64)
Total	165	

Note. Values enclosed in parentheses represent mean square error.
*$p < .05$. ***$p < .001$

Table 15: Adjusted Posttest Means of CSEI Composite Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	66.32	70.22	68.31	6.57*
Control	60.93	61.95	63.77	

*$p < .05$

The F value of 6.57 indicates a statistically significant difference ($p < .05$) between the adjusted post-means of the experimental and control groups, with higher post-means being indicated for the experimental group. Thus, the experimental group's scores on overall (composite) self-esteem appear to be significantly greater, and on that basis hypothesis 2 was rejected.

Hypothesis 3

As stated in Chapter I, hypothesis 3 read as follows: No statistically significant difference exists in the adjusted post-mean scores of a general self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], general self-esteem subscale*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms, using pre-mean scores as the covariate. Testing this hypothesis required an ANCOVA to measure the adjusted post means of the CSEI general section. The results of the CSEI general subscale are indicated in Table 16, and adjusted post mean determinations are shown in Table 17.

Table 16: One-Way ANCOVA of CSEI General Scores by Group

Source	df	F
Group	1	8.85**
Covariate		
CSEI General Pretest	1	81.69***
S = within group error	163	(10.23)
Total	165	

Note. Values enclosed in parentheses represent mean square error.
**$p < .01$. ***$p < .001$.

Table 17: Adjusted Posttest Means of CSEI General Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	16.88	18.21	17.82	8.85**
Control	15.58	15.95	16.33	

**$p < .01$

The F value of 8.85 produced by ANCOVA indicated a significant difference ($p < .01$) between the experimental and control groups. In general self-esteem, it appears that experimental group participants scored significantly higher than their control group peers, thus the results rejected hypothesis 3.

Hypothesis 4

Hypothesis 4 states the following: No statistically significant difference exists in the adjusted post-mean scores of a home self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], home self-esteem subscale*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms, using pre-mean scores as the covariate. ANCOVA was again employed to measure the adjusted post means of the CSEI home subscale. The results of the CSEI home subscale are indicated in Table 18, and adjusted post mean determinations are shown in Table 19.

Table 18: One-Way ANCOVA of CSEI Home Scores by Group

Source	df	F
Group	1	3.56
Covariate		
CSEI Social Pretest	1	65.93***
S = within group error	163	(3.27)
Total	165	

Note. Values enclosed in parentheses represent mean square error.
***p < .001.

Table 19: Adjusted Posttest Means of CSEI Home Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	5.18	5.63	5.48	3.55
Control	4.71	4.80	4.95	

Although the adjusted post-mean of the experimental group appeared to be greater than that of the control group (see Table 19), the resulting F value of 3.55 indicated no significant difference between the two groups when $p < .05$. Home self-esteem was not significantly affected by the treatment given to the experimental group participants. The resulting evidence failed to reject hypothesis 4.

Hypothesis 5

Hypothesis 5 states the following: No statistically significant difference exists in the adjusted post-mean scores of a school self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], school self-esteem subscale*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms, using pre-mean scores as the covariate. ANCOVA was subsequently conducted to measure the adjusted post means of the CSEI school subscale between groups. The results of the CSEI school subscale are indicated in Table 20, and the school subscale adjusted post mean determinations are shown in Table 21.

Table 20: One-Way ANCOVA of CSEI School Scores by Group

Source	df	F
Group	1	3.92*
Covariate		
CSEI School Pretest	1	36.41***
S = within group error	163	(2.99)
Total	165	

Note. Values enclosed in parentheses represent mean square error.
*$p < .05$. ***$p < .001$.

Table 21: Adjusted Posttest Means of CSEI School Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	5.73	5.59	5.44	3.92*
Control	5.08	4.76	4.90	

*$p < .05$.

The F value of 3.92 produced by ANCOVA analysis indicated a significant difference ($p < .05$) between the experimental and control groups. Both groups had lower posttest means than pretest means, but the experimental group had a smaller decrease than the control group. Therefore, considering school self-esteem, experimental group participants scored significantly higher than their control group peers. The data analysis on school self-esteem, as a result, rejected hypothesis 5.

Hypothesis 6

The final self-esteem measure concerned social self-esteem. Hypothesis 6 in Chapter I stated the following: No statistically significant difference exists in the adjusted post-mean scores of a social self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI], social self-esteem subscale*) of students in technology-rich elementary classrooms when compared to students in traditional elementary classrooms, using pre-mean scores as the covariate. Testing this hypothesis once again required ANCOVA processes. The results of the CSEI school subscale are indicated in Table 22, and the school subscale adjusted post mean determinations are shown in Table 23.

As is shown in tables 22 and 23 ($F = .02$), no significant differences were found between the two groups in regard to social self-esteem. Adjusted post-means were nearly identical on this measure, indicating only small gains between test sessions. Therefore, this process failed to reject hypothesis 6.

Table 22: One-Way ANCOVA of CSEI Social Scores by Group

Source	df	F
Group	1	.016
Covariate		
CSEI Social Pretest	1	36.24***
S = within group error	163	(2.43)
Total	165	

Note. Values enclosed in parentheses represent mean square error.
***p < .001.

Table 23: Adjusted Posttest Means of CSEI Social Scores

Group	Pretest Mean	Posttest Mean	Adjusted Mean	F
Experimental	5.45	5.68	5.59	.02
Control	5.07	5.48	5.56	

Hypothesis 7

Hypothesis 7 in Chapter I states the following: There will not be a statistically significant difference between the type of classroom (technology-enriched or non-technology-enriched) and the type of verbal interaction during the fall school session. To test this hypothesis, a 4 X 2 chi-square analysis was conducted on the total observed interactions occurring in the fall. The result (X^2[3, N = 207] = 379.56, $p < .001$) was statistically significant. According to chi-square analysis, there was a difference between the type of classroom (technology-enriched or non-technology-enriched) and the type of verbal interactions (student:student, student:teacher, teacher:student, and teacher:teacher) observed during the fall. Based on these findings, hypothesis 7 must be rejected.

Chi-square analysis does not indicate the precise types of interactions that encouraged such a difference. It was necessary to examine the verbal interaction types in percentages to determine how they related to the fall session observations. Table 24 indicates these verbal interaction percentages as they applied to each group.

Table 24: Classroom Interaction for Experimental and Control Classrooms during Fall, 1998

	Experimental		Control	
Interaction Type	No.	%	No.	%
Student:Student	965	49%	352	21%
Student:Teacher	274	14%	238	14%
Teacher:Student	671	34%	864	52%
Teacher:Teacher	63	3%	221	13%
Total	1973	100%	1675	100%

As is shown in table 24, the majority of observed interactions in the fall occurred in the experimental group Student:Student category (965, 49%), and in the control group Teacher:Student category (864, 52%). The table indicates that the difference between type of classroom and type of verbal interaction is due to the propensity of teacher-initiated dialogue in the control (non-technology-enriched) classrooms and the propensity of student-initiated dialogue in the experimental (technology-enriched) classrooms.

Hypothesis 8

Hypothesis 8 states the following: There will not be a statistically significant difference between the type of classroom (technology-enriched or non-technology-enriched) and the type of verbal interaction during the spring school session. To test the hypothesis, as was done with hypothesis 7, a 4 X 2 chi-square analysis was conducted on the total observed interactions occurring in the spring. Results from the spring (X^2[3, N = 207] = 432.33, p < .001) were also statistically significant. According to the spring chi-square analysis, differences are indicated between the type of classroom (technology-enriched or non-technology-enriched) and the type of verbal interactions (student:student, student:teacher, teacher:student, and teacher:teacher). This evidence was used to reject hypothesis 8.

As was the case in hypothesis 7, however, chi-square analysis was not a sufficient predictor in regard to the precise types of interactions that encouraged such a difference. It was necessary to examine the verbal interaction types in percentages to determine how they related to the spring session. Table 25 indicates these verbal interaction percentages as they applied to each group, and points to results similar to what was found in Table 24. The majority of total observed interactions occurred in the experimental group Student:Student category (745, 51%), and in the control group Teacher:Student category (917, 58%). Again, as was shown in the fall school session (hypothesis 7), the strong difference between type of classroom and type of verbal interaction is largely due to the number of teacher-initiated interactions in the control (non-technology-enriched) classrooms and the number of student-initiated interactions in the experimental (technology-enriched) classrooms.

Table 25: Classroom Interaction for Experimental and Control Classrooms during Spring, 1999

	Experimental		Control	
Category	No.	%	No.	%
Student:Student	745	51%	249	16%
Student:Teacher	185	13%	330	21%
Teacher:Student	448	31%	917	58%
Teacher:Teacher	71	5%	95	6%
Total	1675	100%	1675	100%

Results for Research Question 1

Research Question 1 asked the following: What is the difference in adjusted post-mean scores on a standardized achievement test (*The Iowa Tests of Basic Skills [ITBS]* or the *California Achievement Test [CAT]*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms when using pre-mean scores as the covariate? No statistically significant differences were found between the two groups in regard to reading, while statistically significant differences were found in favor of the experimental group with regard to mathematics scores.

Results for Research Question 2

Research question 2 asked the following: What is the difference in adjusted post-mean scores on a composite standardized self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI]*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms using pre-mean scores as the covariate? Statistically significant differences were found between the two groups in regard to composite self-esteem, with experimental groups possessing the higher adjusted post means.

Results for Research Question 3

Research question 3 asked the following: What is the difference in adjusted post-mean scores on a general self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI, general self-esteem subscale]*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms using pre-mean scores as the covariate? Statistically significant differences favoring the experimental group were found between the two groups concerning general self-esteem.

Results for Research Question 4

Research question 4 asked the following: What is the difference in adjusted post-mean scores on a home self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI, home self-esteem subscale]*) between students in technology-enriched elementary classrooms when compared to students in traditional elementary classrooms using pre-mean scores as the covariate? No statistically significant differences were found between groups regarding home self-esteem.

Results for Research Question 5

Research question 5 asked the following: What is the difference in adjusted post-mean scores on a school self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI, school self-esteem subscale]*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms using pre-mean scores as the covariate? Statistically significant differences were found between the two groups regarding school self-esteem with experimental group subjects holding higher adjusted post means.

Results for Research Question 6

Research question 6 asked the following: What is the difference in adjusted post-mean scores on a social self-esteem assessment (*Coopersmith Self-Esteem Inventories [CSEI, social self-esteem subscale]*) between students in technology-enriched elementary classrooms and students in traditional elementary classrooms using pre-mean scores as the covariate? No statistically significant differences were found in regard to social self-esteem between the two groups.

Results for Research Question 7

Research question 7 asked the following: Is there a difference between type of classroom (technology-enriched or non-technology-enriched) and type of verbal interaction during the fall? A statistically significant difference was found between the type of classroom and fall session verbal interactions, with technology-enriched classrooms consisting of more student-to-student interactions and the non-technology-enriched classrooms consisting of more teacher-to-student interactions.

Results for Research Question 8

Research question 8 asked the following: Is there a difference between type of classroom (technology-enriched or non-technology-enriched) and type of verbal interaction during the spring? A statistically significant difference was found between the type of classroom and spring session verbal interactions, with technology-enriched classrooms consisting of more student-to-student interactions and the non-technology-enriched classrooms consisting of more teacher-to-student interactions.

CHAPTER V

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

This chapter examines the review of literature and offers conclusions and interpretations based on the obtained results. Implications of the study as well as recommendations for further research are then proposed to aid future efforts of scholarly study. Finally, conclusions are presented to provide a holistic set of meanings to the totality of research conducted herein.

The purpose of this study was to determine the impact of classroom technology on the accomplishments of elementary students, as well as the sense of worth those students held as a result of that exposure to technology. A comparison of the attainments of elementary students in technology-enriched elementary classrooms and the attainments of students in traditional (not technologically-enriched) elementary classrooms was conducted while considering the following areas: student achievement (as measured by standardized scores in mathematics and reading), self-esteem, and classroom interactions. Participants in the study were from 10 classrooms (five technology-enriched environments and five without such technology) at 5 elementary schools in 5 Louisiana parishes. The independent variable was the use of technology in classrooms, and the dependent variables were student achievement, student self-esteem, and classroom interaction patterns.

The review of literature acknowledged a quantity of mixed results among studies measuring technology-integration and student achievement. Even among studies that report positive results for such integration, numerous detractors have also been present who claim unsound research methodologies are involved with those reports. Early Apple Classrooms of Tomorrow projects met with promising results concerning instructional technologies, and cooperative learning methodologies appear to have produced great learning effects when paired with computer technology. The literature also reports that self-esteem can and has been positively raised as a result of working within computer environments. Although limited evidence appeared to support a conclusion that computer technology directly initiated student-centered interactions in classroom settings, some studies (Cummings, 1986; DeGraw, 1990; Lehrer & Randle, 1987; Levin, et al., 1989; Nastasi, et al., 1990; Pagliaro, 1979; Repman, 1993; Riel, 1989; Saye, 1997) did suggest such a connection, and the cooperative nature of most school-related computer environments appears to add merit to such logic.

A quasi-experimental design of the time-series type was utilized in this study to determine the effects of classroom technology on the achievement, self-esteem, and interaction patterns of the elementary participants involved. Threats of internal validity, including maturation, testing, instrumentation, regression, selection, mortality, and the interaction of selection and maturation were found to be minimal although the threat of history was found to be of some concern. History was controlled by allowing only a nine-month time period between researcher measurements. Random assignment to either experimental or control groups was conducted at the beginning of the 1998-99 school year, and then data were collected from achievement test scores, self-esteem scores, and classroom interaction observations.

Experimental-group teachers in low-socioeconomic elementary schools (determined by free and reduced lunch counts) participated in proficient training in instructional technology prior to the 1998-99 school year. Before the school year began, a considerable amount of classroom technologies were installed into these teachers' classrooms, including computers, internet connections, printers, televisions, projection systems, scanners, digital cameras, VCR's, videoconferencing equipment, and software. Once the school year commenced, these teachers integrated a variety of technology tools and teaching strategies into their curriculum, primarily in the science, mathematics, and language arts areas, and allowed students to use the technology on a regular basis. Control group teachers conducted their classroom teaching in the traditional manner, and little or no technology access was provided for their classroom environment. Achievement test scores, self-esteem scores, and interaction analysis observations were then collected from the experimental and control groups, and analysis of these data was conducted to determine the possible effects of the technology.

Conclusions

After technology was incorporated into low socioeconomic elementary classrooms, this study addressed three main areas in elementary education that are of concern to educators and scholars: achievement, self-esteem, and classroom interactions. These areas of concern are now presented as they relate to previous research conclusions as well as the results of this study. The conclusions established in this section are based on the research questions and hypotheses stated in Chapter I. Conclusions are presented for reading and mathematics achievement results first, followed by self-esteem results (including all subscale self-esteem analyses) and classroom interaction results.

Results from the reading achievement segment of this study were used to test the hypothesis that student scores on a standardized achievement test would differ significantly depending on placement in a technology-rich classroom. The ITBS Reading Total analysis revealed no significant difference at the $p < .05$ level, but the CAT Vocabulary and CAT Comprehension analyses revealed a statistically significant difference ($p < .001$). Because the CAT was utilized in only 1 of the 5 schools tested in this study, and because in the majority of classrooms students appeared to score similarly by group, it is thus necessary to state that no significant differences were found on this measure.

The reading achievement results of this study present difficult questions, perhaps most importantly: Why did CAT reading scores result in significant differences by group while ITBS reading scores did not? The answer may lie in the fact that the ITBS assessment is a fairly new evaluation instrument in Louisiana schools, having been instituted for the first time in 1998-99 when pretest data were collected from participants in the 4 schools taking that examination. The ITBS is also a test of higher-order thinking skills, as opposed to the CAT's emphasis on recall of facts. School D's participants, on the other hand, were well accustomed to the format of the CAT examination (this conclusion is weakened by the fact that significant differences in mathematics achievement were found in both the ITBS and CAT examinations). In addition, it should also be noted that School D was the only rural school in the study, which might account for differences in reading achievement when compared to the more urban school settings.

Data from the mathematics achievement section of this study were also used to test the hypothesis that student scores on a standardized achievement test would differ significantly depending on placement in a technology-rich classroom. The ITBS Mathematics Total breakdown indicated a statistically significant difference by group ($p < .05$), and the CAT Mathematics Concepts and Applications examination, as well as the Analytical Mathematics examination, revealed significant differences ($p < .001$ for each) as well. Participants in the technology-enriched classrooms appeared to score significantly higher in mathematics achievement than their peers in the non-technology-enriched classrooms. These results supported the findings of Burns and Bozeman (1981), Ross, Smith, Morrison, and Erickson (1989), Baker, Gearheart and Herman (1994), Grimm (1995), Gardner, Simmons, and Simpson (1992), Christmann, Badgett, and Lucking (1997), Christmann, Lucking, and Badgett (1997), Kulik, Kulik, and Bangert-Drowns (1985), Ryan (1991), Kulik and Kulik (1991), Liao (1992), and Mann and Shafer (1997), all of whom found significant differences between the test scores of technology-enriched classrooms and control classrooms without such technology. The present study's findings are contradictory to the findings of and arguments presented by Jones and Paolucci (1998), Hattie (1991), Clark, (1994) Holden (1989), Jegede and Okebukola (1989), Kristianson (1991), Miller (1992), Snowman (1995), Weizenbaum (1997), Parry et al., (1986), and Krendl (1986), who either found insignificant evidence that technology-enhanced classrooms effect achievement or make the claim that unsound research methodologies are to blame for the positive reports of educational technology effectiveness.

In regard to the specific effects that technology-enriched classrooms appear to have on the mathematics achievement of this study's participants, there is much support in the literature. Burns and Bozeman's (1981) meta-analysis of mathematics-related CAI studies found strong evidence that computer-inclusion was instrumental to a significant rise in elementary mathematics achievement, and Clements, Nastasi, and Swaminathan (1993), Funkhauser (1993), Maverech, et al. (1991), Reglin (1989), Repman (1993), Riel and Harasim, (1994), and Tyler and Vasu (1995) report significant gains in mathematics achievement as a result of classroom technology infusion.

Results of the data analysis in mathematics achievement present important findings. Mann and Shafer (1997), among others, also found that when technology was introduced to the classroom environment, profound effects on achievement were observed, especially in the area of mathematics. Since the 1950s, an emphasis has been placed on the improved mathematics achievement of America's students, and technology inclusion appears to be an answer in improving those skills. This research provides additional evidence that technology-enriched classrooms will assist in accomplishing the mathematics achievement goals of this nation, especially among low socioeconomic students.

Regarding self-esteem, the data obtained from the composite self-esteem section of this study were used to test the hypothesis that student scores on the composite section of a standardized self-esteem assessment would differ significantly depending on placement in a technology-rich classroom. The CSEI Composite results and analysis indicated significant differences by group ($p < .05$), with experimental-group students scoring higher in adjusted post-means. Thus, students in this study's technology-enriched classrooms scored significantly higher in overall self-esteem than their control-group counterparts. Results from the general self-esteem section of the CSEI were used to determine student self-esteem in general, or student self-esteem not bound by the individual subscales of home self-esteem, school self-esteem and social self-esteem. CSEI general self-esteem scores and analyses were also used to test the hypothesis that student scores on the general section of a standardized self-esteem assessment would differ significantly depending on placement in a technology-rich classroom. The CSEI general self-esteem analysis indicated significant statistical differences by group ($p < .01$), with experimental participants scoring higher on adjusted posttest means. Results from the school self-esteem section of the CSEI were used to determine student self-esteem in regard to school life and to test the hypothesis that students' scores on a school self-esteem assessment would differ significantly depending on placement in a technology-rich classroom. CSEI school data analysis indicated significant differences ($p < .05$) between the two groups, with the experimental group holding higher adjusted post-means. Although scores for both groups declined from pretest to posttest (which might be explained by noting the excitement many students feel regarding school at the beginning of the school year as opposed to the end of the school year), students within the technology-enriched classrooms obtained significantly higher school self-esteem scores than those who were not exposed to the enriched classrooms.

Regarding the three preceding measures of self-esteem and their results, it can be concluded that technology-enhanced classrooms aid in raising the self-esteem levels of low socioeconomic elementary students and that efforts to utilize and encourage their use should be underway immediately throughout our nation's schools to incorporate this use. If technology-enriched classrooms help to raise the self-esteem levels of the students involved (which is supported by this study's evidence), and if increased self-esteem is viewed as a precursor to a rise from poverty (Glenn, Johnson, & White, 1992; Lehrer & Randle, 1987; Reglin, 1989) then increased technology in American classrooms can be seen as an important step for low socioeconomic citizens to rise up from that poverty. Gardner, Simmons, and Simpson (1992), as well as Lehrer and Randle (1987), also suggest that such computer environments, after aiding the knowledge-gain of the participants involved, encourage lifelong learning habits and increase commitment for further learning, or "learning to learn," which can be related to the student's self-esteem. Signer (1991) provides further evidence that when classroom technologies lower the dropout rates of students, self-esteem is a major factor within that decision-making process. Classroom computing, self-esteem levels, dropout rates, and lifelong learning, it is thus concluded, are all very much intertwined.

Data from the home self-esteem section of this study were used to test the hypothesis that students' scores on a home self-esteem assessment would differ significantly depending on placement in a technology-rich classroom. The CSEI home subscale analysis indicated no significant differences in home self-esteem scores at the $p < .05$ level, thus indicating that students in the technology-enriched classrooms did not score significantly higher in home self-esteem than their peers in the non-technology-enriched classrooms. Data obtained and analyzed from the social self-esteem subscale of the CSEI were used to test the hypothesis that students' scores on a social self-esteem assessment would differ significantly depending on placement in a technology-rich classroom. Results of the CSEI social data analysis indicated no significant difference at the $p < .05$ level between the two groups. Technology-enrichment, it appears, had no effect on the self-esteem students developed at their homes or with peers during the school year. While further study is needed to replicate these results, the time-of-year factor (where school was to be soon dismissed for the summer) may have had an effect.

The findings of this study are in concert with literature suggesting that computer-enriched classrooms produce significantly higher self-esteem levels (Repman, 1993; Ryser, 1990; Robertson, Ladewig, Strickland, & Boshung, 1987; Tyler and Vasu, 1995; Haugland, 1992; DeGraw, 1990). Silver and Repa's (1993) study contradicts this study's findings, but it should be noted that Silver and Repa only focused on the word-processing component of classroom computing and did not consider collaborative-type activities in data collection and analysis.

The various self-esteem subscale analyses conducted here, although interesting, should also be viewed as adding to the whole of the self-esteem findings. For example, this study found that significant differences existed by group in regard to CSEI composite scores ($p < .05$). Other significant differences were also found with school self-esteem ($p < .05$) and general self-esteem ($p < .01$), but no significant difference was found with either home self-esteem or social self-esteem. The 4 subscale results may thus be seen as indicating the direction that overall self-esteem (composite scores) would turn.

Observation data obtained and analyzed during the fall school semester were used to test the hypothesis that a statistically significant difference would be found between the type of verbal interaction and the presence or absence of technology-enrichment in the classroom. Results of the statistical analysis on data collected via an adaptation of Flanders Interaction Analysis System (FIAS) revealed a significant difference between type of classroom and type of verbal interaction ($p < .001$). Upon observing the actual percentages of each group's interactions during the fall, it was determined that disproportionate amounts of student-to-student verbal exchanges occurred in the technology-enriched classrooms (49%), and that disproportionate amounts of teacher-to-student verbal exchanges occurred in the non-technology-enriched classrooms (52%).

In the same way, observation data obtained and analyzed during the spring school semester were used to test the hypothesis that a statistically significant difference would be found between the type of verbal interaction and the presence or absence of technology-enrichment in the classroom. Results of the statistical analysis on data collected via an adaptation of Flanders Interaction Analysis System (FIAS) revealed a significant difference between type of interaction and type of verbal interaction ($p < .001$). Upon observing the actual percentages of each group's interactions during the spring, it was determined that disproportionate amounts of student-to-student verbal exchanges occurred in the technology-enriched classrooms (51%), and that disproportionate amounts of teacher-to-student verbal exchanges occurred in the non-technology-enriched classrooms (58%).

During the fall and spring school semesters, students in the technology-enriched classrooms initiated and responded to other students significantly more than their control group peers, and student participants without technology-enrichment responded to teacher-initiated classroom dialogue significantly more than their peers with technology-enriched classroom settings. The experimental-group teachers, it should be noted, were not specifically trained in methodologies relating to how and when to question students, or even how to involve groups of students. A conclusion can therefore be made that quality learning was taking place in those technology-enriched classrooms. As Keller (1968) suggested, children learn best from other children, and this study further suggests (as did Jonassen, Campbell, & Davidson, 1994 and Swan & Mitrani, 1993) that classroom settings with technology-enrichment are more likely to produce those learning situations. These findings provide further evidence that cooperative computing environments appear to be catalysts for student-initiated communications (see also Carlson, et al., 1998; Clements, Nastasi, & Swaminathan, 1993; Cohen, 1997; Riel, 1989; Yelland, 1995).

The results of classroom interaction analysis conducted in this study point clearly to technological influences in the fall and spring semesters. Technology-enriched classrooms were far more likely to consist of a student-initiated environment where students participated in teacher-led instruction but also student instruction in the form of computer workgroups. The literature reports many similar study outcomes: technology-enriched classrooms were prone to produce more student-centered and individualized interactions and non-technological classrooms consisted of the traditional model of teacher-centeredness (Carlson et al., 1986; Clements, Nastasi, &

Swaminathan, 1993; Cohen, 1997; Jonassen, Campbell, & Davidson, 1994; Reil, 1989; Swan & Mitriani 1993). It has been shown previously (Mevarech, et al., 1991; Meverich, Stern, & Levita, 1987; Ryba, Selby, & Nolan, 1995) that when students work in cooperative computer groups, as opposed to working alone at computers, significantly more learning takes place as the result of student interaction. This study's findings in regard to interaction patterns in technology-enriched and non-enriched classrooms are strong indicators that technology may impact the classroom learning process.

In addition, the classroom interaction results, when joined with the mathematics achievement and self-esteem findings, produce an interesting set of considerations when viewing the literature. Flanders (1967) found that increased achievement existed within environments where student-initiated communications were allowed to exist. This study's experimental (technology-enriched) classrooms were focused on student-centeredness. If student-centered classroom environments tend to produce higher student achievement (as seen in this study's findings on mathematics, as well as in Flanders' analysis), and these environments also coexist with students with significantly higher self-esteem levels, and if higher self-esteem tends to produce higher achievement (Beane & Lipka, 1986; Bruck and Bodwin, 1962; Gordon & Brown, 1993; Samuels, 1977; Winne, Woodlands & Wong, 1982), then a cycle may exist with implications that deserve close attention, as well as further study. Furthermore, if it is concluded that increased student-to-student interactions promote increased student achievement, and if it is concluded that increased classroom technologies promote higher student-to-student classroom interactions, then a logical conclusion can be made to further support classroom integration of technology: classroom technology promotes higher student achievement.

Implications for Practice

After consideration of the findings of this study, when paired with the results gathered from previous educational technology efforts, the following recommendations are offered:

1. Schools should strive to obtain additional educational technologies, especially computers, for classroom use at the elementary level. Haugland and Shade (1990) and Ainsa (1995) suggested that children be exposed to such technologies as soon as they enter school so as to maximize the potential for future learning opportunities. As this study found, mathematics achievement, self-esteem, and student-centered learning can be positively affected with such integration.

2. School systems should provide adequate training to teachers in regard to the integration of educational technologies into the curriculum. The present study's experimental-group teachers were previously involved in intense training workshops where such training focused on the practical classroom applications of computer hardware, software, and peripherals.

3. School systems, after allocating the aforementioned technology enhancements to classrooms, should provide the necessary technical support and administrative support at the local level, and ongoing support networks of teachers should be constructed and maintained by individual districts.

4. The presence of classroom technology appears to have a significant effect on the mathematics achievement of low socioeconomic elementary school students

Schools should therefore take steps to obtain the necessary hardware and software to accommodate these students.

5. The presence of classroom technology has a positive effect on the overall self-esteem, the general self-esteem, and the school self-esteem of low socioeconomic elementary school children. Educators should make every effort to obtain these tools to enhance the self-esteem levels of their students.

6. The presence of classroom technology has little or no influence on the self-esteem of elementary school children in the home environment or in a social sense. Further research is needed to prove or disprove these findings.

7. The presence of classroom technology encourages more student-initiated comments and questions to other students in the classroom. Students in a technology-enriched classroom appear to take greater control of their learning than do students without that inclusion, and students using classroom technologies are more likely to turn to their peers for collaborative problem-solving efforts than to the teacher for immediate solutions to problems. Based on this study's observations, elementary classrooms that do not utilize technology in the curriculum tend to operate in the traditional mode of teacher-questioning and student-response. Students in non-technology-enriched classrooms tend to be dependent on the teacher for the knowledge acquisition on all tasks. Schools should therefore strive to include as much technology as is possible in individual classrooms and make commitments to allowing learners the opportunities to direct more of the learning process.

Recommendations for Research

Based on the results of this study and previous studies involving student performance with or without the presence of classroom technology, the following recommendations are offered to future researchers.

1. Research should be conducted in an effort to replicate this study's positive conclusions regarding classroom technology. Hattie (1991) and Jones and Paolucci (1998) claimed that very few *valid* studies existed that pointed to positive relationships between classroom technology and student learning, and more research should be offered that involves close scrutiny of those validity threats. In addition, because many researchers (Kennett, 1991; Kozma, 1994; Valeri-Gold & Deming) suggest that schools are in the birthing pains of the technological revolution, whereby computer methodology takes considerable time to develop, a repetitive series of studies is needed to examine that possibility.

2. The effects of classroom technologies on content areas not covered by data analysis, especially social studies, should be further examined. In regard to science, several studies (Barba & Merchant, 1990; Geban, Askar, & Ozkan, 1992; Lazarowitz & Huppert, 1993) have demonstrated positive technological effects on achievement, and writing has also been shown to be significantly affected in this way (Chavez, 1990; Silver and Repa, 1993; Zellermayer, et al., 1991). It would be beneficial to include these two areas in a similar study on classroom technology effects.

3. Research should be conducted to determine the effects of increased or decreased teacher training in technology integration on the mathematics achievement, self-esteem, and classroom interactions of students.

4. Further research is needed in an attempt to replicate the classroom interaction findings of this study. Studies should focus on whether classroom technologies promote the presence of a more student-centered classroom where opportunities for student interaction, problem-solving, and critical thinking exist, and whether non-technology-enriched classrooms tend to adhere to the traditional teacher-centered format of instruction.

5. Additional research studies should examine whether computers in students' homes have further effects on mathematics achievement, self-esteem, and classroom interaction patterns.

Final Conclusions

This study indicated that technology-enriched elementary classrooms are conducive to higher mathematics achievement levels, higher self-esteem levels, and student-centered environments among low socioeconomic status elementary children. This conclusion is based on the results of data analysis on achievement in reading and mathematics, on overall self-esteem, on sub-level self-esteem categories, and classroom interaction patterns from the fall of 1998 to the spring of 1999. Children in technology-enriched classrooms appear to perform higher on standardized tests in mathematics, to take control of their own learning environment, to work well in cooperative groups to accomplish a common task, and to place worth in their ability to be productive students and citizens.

As the new millenium progresses, educators will no doubt be confronted with additional claims of technological ineffectiveness in classrooms, invalid research studies concerning educational technologies, and the erroneous allocation of educational funds into needless technological pursuits at the expense of traditional classroom funding necessities. These allegations should not be taken lightly because great quantities of public resources have and will continue to be deposited into educational technology. It is also true that while classroom technology may not be the cure-all for many educational ills, it does appear to significantly affect low socioeconomic elementary students in academic achievement and self-esteem.

APPENDIX A

FLANDERS INTERACTION ANALYSIS SYSTEM (FIAS)

Table 26: Flanders Interaction Analysis System (FIAS)

Teacher Talk	Indirect Influence	1. Accepts Feeling: accepts and clarifies the feeling tone of the students in a non-threatening manner. Feelings may be positive or negative. Predicting or recalling feelings are included. 2. Praises or Encourages: praises or encourages student action or behavior. Jokes that release tension, not at the expense of another individual, nodding head or saying "um hm" or "go on" are included. 3. Accepts or Uses Ideas of Student: clarifying, building, or developing ideas or suggestions by a student. As teacher brings more of his ideas into play, shift to category five. 4. Asks Questions: asking a question about content or procedure with the intent that a student answer.
		5. Lecturing: giving facts or opinions about content or procedure; expressing his own ideas, asking rhetorical questions. 6. Giving Direction: directions, commands, or orders to which a student is expected to comply. 7. Criticizing or Justifying Authority: statements intended to change student behavior from non-acceptable to acceptable pattern; bawling someone out; stating why the teacher is doing what is being done; extreme self-reference.
Student Talk		8. 8. Student Talk – Response: talk by students in response to teacher. Teacher initiates the contact or solicits student statement. 9. Student Talk – Initiation: talk by students which they initiate. If "calling on" student is only to indicate who may talk next, observer must decide whether student wanted to talk, if student did, use this category.

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APPENDIX B

RECORDING FORM FOR ADAPTATION OF FLANDERS INTERACTION ANALYSIS SYSTEM

RECORDING FORM FOR ADAPTATION OF FLANDERS INTERACTION ANALYSIS SYSTEM

Activity	Student:Student	Student:Teacher	Teacher:Student	Teacher:Teacher
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸
	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸	𝍸 𝍸 𝍸

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VITA

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Mr. Page first became interested in educational technology in the mid-1990s. After undergoing extensive training in Internet-based technologies as they related to education, he completed the state requirements for computer literacy and computer science certification and trained Louisiana teachers in the processes of integrating the Internet into classroom environments. In 1998, Mr. Page had his first article, "Conflicts of Inequity: Educational Technology in America" published in a nationally refereed journal, *Computers in the Schools* volume 14, number 4. Later in 1999, Mr. Page's second article appeared as a single-authored chapter in the first volume and first issue of a new international refereed journal: *Information Technology in Childhood Education*

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