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A Study of a Specific Language Arts and Mathematics Software Program: Is There a Correlation Between Usage Levels and Achievement?

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A STUDY OF A SPECIFIC LANGUAGE ARTS AND MATHEMATICS SOFTWARE PROGRAM: IS THERE A CORRELATION BETWEEN USAGE LEVELS AND ACHIEVEMENT?

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The purpose of this study was to compare usage levels of CompassLearning Odyssey mathematics and language arts software among fifth grade students in order to determine the relationship between usage and achievement. While educational software designed by various companies is a regular part of daily instruction in most public schools across the United States, there remains a need for research-based evidence of the efficacy of specific programs. This study used a quantitative design to compare achievement gains between 280 fifth grade students who had varying degrees of access to the software.

Being an *ex post facto* design, the study used data from students in five elementary schools in one district. Having partnered with state-supported independent researchers for the Enhancing Education through Technology (EETT), the district had already divided classes of teachers and students into groups that used CompassLearning software in one of three ways: mathematics only, language arts only, and both mathematics and language arts. This arrangement allowed the study to more easily examine whether or not the correlation between usage and achievement scores varied by subject area.

The study used independent t-tests to discern the relationship between usage and achievement. To nullify the effects of demographic variables of gender, SES, identification as learners with special needs, and prior achievement levels, ANCOVA analyses were conducted.

Results showed a significant relationship between CompassLearning Odyssey language arts and mathematics software and achievement as measured on the Pennsylvania System of School Assessment (PSSA). An interesting result was the finding that, on the PSSA reading posttest, users of mathematics software outperformed users of language arts software. Both groups showed greater gains than did students in the server-based version of the software.

Regarding demographic variables, gender had no effect on achievement gains. The effect of socioeconomic status was significant among users of mathematics software; conversely, the effects of prior achievement level and identification as learners with special needs were significant among users of language arts software.

This study supports the hypothesis that educational software enhances student achievement. Evidence gained in this study also identifies areas of technology-based instruction in need of further study.

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The now-familiar African proverb, “It takes a village to raise a child” can easily be applied to the support I experienced as I progressed through this dissertation. While I reap the benefits, I cannot claim full credit for having attained my life’s dream of earning a doctoral degree. In addition to providing me with sound advice, Dr. George Bieger, my dissertation chair, Dr. Valerie Helterbran and Dr. Erick Lauber, committee members, were responsive to my requests for feedback throughout the research and writing process. I owe a special note of appreciation to Dr. Wenfan Yan who gave me the opportunity to design and conduct research with him; this experience gave me the courage to attempt a quantitative research project. Members of the Applied Research Lab at Indiana University of Pennsylvania, and Tina Rose in particular, filled the gaps of my understanding of statistical analysis.

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CHAPTER I

OVERVIEW OF THE STUDY

In the United States and other industrialized nations, computers have become a part of mainstream life. According to Newburger (2001), the 2000 U.S. Census showed that 51% of households in the United States had computers; about 41.5% of American households had access to the Internet. DeBell and Chapman (2006) note that home computer ownership, type of use, and access to the Internet vary significantly along lines of family income and ethnicity. While such disparity bodes poorly for those in education who work to provide equity for all children, it is heartening to note that ethnicity and socioeconomic status are not factors in the degree and type of computer use and access to the Internet by children in public schools (p. 13). So, while home access for certain groups is more limited than for others, the field is leveled during the time that children are in school.

While arguments for—and against—computers in the classroom abound, this form of technology continues to play an increased role in the education of American children. In 1995, public schools reported having one computer for every 11 students; very few classrooms contained more than one computer, and only about 32% of schools had Internet access (Mendels, 1999). These numbers have increased significantly: according to the National Center for Education Statistics (2004), 93% of American public schools had computers in 2003; 90% of all public schools had Internet access. In terms of access to these computers by students, the ratio of one computer for every 11 students in 1995 had dropped to one computer for every six students by 1999 (Mendels, 1999). In schools with computers, 93% of instructional classrooms were connected to the Internet (DeBell & Chapman, 2006).

The U.S. Department of Education is actively working to put technology in the form of computers and peripherals into classrooms. The Goals 2000: Educate America Act (2004) allocated specific funds to the dissemination of technology and related training to schools. The National Education Technology Plan of 2004 outlines a process for using technology to bridge the achievement gap that exists between various groups of learners (U.S. Department of Education, 2004). In this plan, Pennsylvania is one of several states that have initiated broad programs aimed at putting computers and Internet access in the hands of students and families that don't currently have such technology at home.

Statement of the Problem

The current practice of using scores on standardized tests to determine whether or not schools and students are successful means that most of a school's practices are geared to helping students perform well on such assessments (Mcneil, 2000; Saiger, 2005). This being the case, and with programs and money being designated specifically for infusing technology into the classroom, the actual effectiveness of technology in helping students reach achievement goals is an area in need of study. The question, then, is: how effective is the use of such technology in raising student scores on standardized assessments? According to a Rand report (Skinner, 1999), there had been no large-scale investigation into the effect of computers on student achievement during the 1990s and early twenty-first century. More recently, groups such as the What Works Clearinghouse (WWC) and the North Central Regional Educational Laboratory (NCREL)s have conducted studies of specific software packages that are intended to improve student achievement on state standardized assessments. Even so, many of the purported benefits to students, of software in use by school districts today, are not validated by rigorous and objective analysis (What Works Clearinghouse, 2002). With current emphasis on student performance on standardized tests as indicators of overall efficacy for learners, teachers, and entire school districts, it is incumbent on all stakeholders to ensure that the time, money and training spent on technology are indeed a worthy investment.

The Purpose of this Study

The issue to be addressed in this study is the effectiveness of a specific technology software tool in enhancing student learning as measured by state-mandated achievement tests. The value of such a study is twofold. First, with steadily increasing amounts of money being spent to bring computers, Internet access, and technology training into classrooms across the country, it is incumbent on the recipients of such products and services to validate their expenditures. Second, since student performance on achievement tests is equated to success or failure for entire school districts, districts themselves benefit from implementing programs that lead to desired performance results. Knowing the efficacy of technology as a tool that leads to improved scores on standardized tests will help districts justify or discontinue the infusion of specific technology into classrooms.

The specific technology interventions under examination were the Grade Five Compass Learning Odyssey language arts and mathematics programs. It was reasonable to examine this software because the product has a strong presence in Pennsylvania schools. According to CompassLearning regional representative Krall (S. Krall, personal communication, September 26, 2006), the original server-based CompassLearning software product had been purchased by 782 schools; these are still in use in many schools. In addition to these, Krall states that 375 Pennsylvania schools currently use the online CompassLearning Odyssey product. To show the significance of these numbers, one must consider that there are 3,253 public schools in Pennsylvania. Using only the number of schools that used the server CompassLearning product, one can see that this translates to 24% of all Pennsylvania public schools adopting the CompassLearning software. The number will be larger if one includes schools that use CompassLearning Odyssey. Further evidence that this software is part of the curriculum in many school districts, a cursory examination of the vendors in attendance at the Pennsylvania Educational Technology Expo and Conference (PETE & C) included 36 educational software vendors. Amid such competition, CompassLearning and Compass Learning Odyssey are clearly one of the state's most widely-used software products. With such a widespread investment in a particular learning software product, school districts in this state will benefit from the results of a study that examines the circumstances under which such software is most effective.

Issues of Money

In education, federal and state funding for programs is often tied to specific processes. Over the course of the past several years, federal and state agencies have provided money in the form of competitive grants that require recipients to spend funds according to specific guidelines. For example, the Pennsylvania Department of Education's Enhancing Education Through Technology (EETT) grants, awarded to dozens of schools in 2004, required that 25% of funds be used to provide professional development to teachers and administrators, 10% to pay a project coordinator, and another portion of the grant to pay an outside evaluator whose task was to measure the results of the project. Remaining money was to be used to provide the materials and services, as outlined in the grant proposal, necessary to achieve the projected performance outcomes.

The federal education budget proposal for 2005 was $57.6 billion. Of this, $496 million was designated for technology in education (Murray, 2004). This amount represented the first decline in funding for educational technology since 2001. In order to ensure continued allocation of funds to technology, there exists a need to verify the effectiveness of such interventions in improving student achievement.

Technology-in-education funds are most often allocated to individual states who then distribute the money among school districts. The push for accountability has led to a process of distributing these funds via competitive grants. School districts write proposals for projects; state education departments then evaluate proposals and allocate money according to the perceived quality of submitted proposals. Quality, of course, is measured by projected increases in student performance on state assessments. Further, the awarding of competitive grants is often contingent on a promise of matching funds on the local level. Having procured the foundations of a technology-rich learning environment through Goals: 2000 and other similar initiatives, school districts are now faced with technology purchases, upgrades, and maintenance as a regular—and expensive—part of their yearly budgets. At this time, however, research that ties technology use directly to student improvement on state achievement tests is limited (Baker & O’Neil, 1994).

Without statistical evidence that technology leads to achievement gains, schools are questioning the need for such costly instructional and learning tools.

Issues of Student Performance

Despite seemingly large sums of money being earmarked for education, the perennial lament among educators is that too little money is spent educating America's youth. They claim that performance expectations are unreasonable in an environment that sets a low price tag on helping learners reach ever-higher achievement standards. The counterstatement is that money should not be given to schools whose students perform poorly on statewide assessments. Politicians and others who control federal, state and local educational purse strings, state that funding cannot be provided until/unless student outcomes warrant the expenditure (Saiger, 2005). With teachers, administrators and entire school districts being held accountable for student achievement outcomes, as measured on standardized tests, it becomes necessary to ensure that most school activities are directly related to achievement outcomes. It follows, then, that the effectiveness of technology as an integrated instructional tool should be evaluated in order to justify or discontinue its use on the basis of its proven positive/negative impact on desired student achievement outcomes.

With a significant number of education dollars attached to technology, it behooves those involved in education to ensure that the money is having the desired effect. Equally important, it is valuable to determine whether or not the intervention of technology, in the form of computers, Internet access, and home-school connectivity is beneficial to all learners.

This study sought to determine whether or not the level of use of technology, as an integrated instructional tool, leads to enhanced achievement among all learners. Using a quantitative design, the study focused on fourteen classrooms of fifth grade elementary students in one public school district. The Pennsylvania System of School Assessment (PSSA) was the primary measure of comparison between groups. An ancillary measure included 4Sight assessments.

In addition to exploring the extent to which technology affected academic outcomes, this study compared results among students based on gender, socioeconomic status, identification as students with special needs, and previous achievement levels as measured by using the Grade Three PSSA scores of participants as a pre-test and the Grade Five PSSA scores of the same students as a post-test.

Significance of the Study

Glennan (1996) proposes that the ideal measure of the effectiveness of technology as an instructional tool would involve a comparison between experimental and control groups of students within schools across the country. Rand acknowledges that such a project is too massive to be undertaken by any group or agency. This study, though on a smaller scale, involved control and experimental groups of students within multiple elementary schools of a school district. Half of the groups used only the language arts portion of the software while the other half used only the mathematics portion of the software. Results will provide information that can be reliably applied to similar student populations in other areas. As comparable research is conducted in other regions, the body of knowledge about the efficacy of specific software will expand to a level of usefulness to educators and school districts. This process has the potential to provide data to represent the national implications of the effect of technology on student achievement about which Rand speaks. The examination of outcomes based on SES, gender, identification as students with special needs, and previous achievement levels will account for some of the factors that might influence results.

Research Questions

According to former Department of Education Secretary Rod Paige (U. S. Department of Education, 2004), the use of technology as an integrated part of curriculum leads to measurable improvement in students' performance on state assessments. The fact that this is a widely accepted premise is evidenced by federal and state dissemination of funds to projects that involve the integration of technology with curricula. Similar statements can be found among software developers and computer manufacturers. Yet, after a quarter century of growing integration of computers with instruction, there is relatively little valid research to support these claims (Skinner, 1999). This situation has led to the reexamination of the place technology should hold in public education. This study examined the use of a specific software product in order to determine its ability to help students achieve to higher levels on the PSSA. The study looked at the PSSA scores of groups of students that either used the product consistently according to the developer's recommendation or did not use the product at all. Following are the hypotheses posed in this study:

1. There is no significant correlation between level of use of CompassLearning Odyssey language arts software and PSSA reading scores.
2. There is no significant correlation between level of use of CompassLearning Odyssey mathematics software and PSSA mathematics scores.

3. Gender has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
4. Gender has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software in PSSA achievement scores in mathematics.
5. SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
6. SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.
7. Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
8. Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.
9. Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.

10. Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.

Definition of Terms

In order to clarify the context in which ambiguous, broad or unknown terms are situated within a research study, it is necessary to describe tools, processes, and unfamiliar acronyms. Several terms will be defined here in order to narrow their meaning within the context of this study:

Computer-Aided Instruction (CAI). This term is used to describe the systematic application of technology-based instructional, remedial, and assessment tools to classrooms.

CompassLearning Odyssey. CompassLearning Odyssey is the name of the software products being examined in this study. CompassLearning, part of the Weekly Reader Corporation, has provided language arts, mathematics, social studies, and other curricular software since the early 1980s. Initially, the product was server-based and therefore self-contained in each school or district. The Odyssey product, similar to its predecessor, consists on an Internet-accessed array of curricular, assessment, record-keeping and professional support tools. This study focused on the language arts and mathematics elements of the Odyssey product. Included in the Odyssey package were instructional modules, individualized learning paths through which students are afforded additional instruction in areas of need, as well as assessment and reporting tools.

EETT. This acronym represents the Enhancing Education Through Technology Act of 2001. EETT provided seed money to school districts that developed technology projects that met rigorous requirements of implementation, professional development, and evaluation.

4Sight Assessment. The product of Johns Hopkins University, 4Sight assessment tools were designed to reflect the Pennsylvania System of School Assessment. Administered quarterly, the assessments are intended to provide educators with formative data about student progress toward state achievement goals.

Interactive Computer Technology (ICT). The phrase "Interactive Computer Technology" is used to describe computer software and other tools that base instruction or other output on the user's earlier responses to instruction or questions. In the case of CompassLearning Odyssey software, a student's correct response to a query might lead to a reinforcing statement and a new piece of information or to the next question in a quiz. An incorrect response might lead to a short tutorial or to the lesson that preceded the question; this might be followed by a second opportunity for the student to give the correct response to the initial question. This process leads the software to create a learning path that focuses specifically on the identified learning needs of each student user.

Jostens Learning. In 2000, the name of the software provider Jostens Learning Center, having been bought by Ripplewood Holdings LLC in 1999, changed its name to CompassLearning. Discussion in Chapter III will include the names of both companies as they relate to the implementation of technology software in the district's elementary schools.

Level of use. CompassLearning Odyssey software tracks the amount of time students spend on each activity. For this study's purpose, duration was measured in two ways: total number of minutes spent using the software and minutes per activity. These are further described in Chapter III.

Previous achievement level. Students' third grade PSSA scores formed the basis for pairing members of control and experimental groups according to previous achievement levels.

School Ability Index (SAI). The School Ability Index, part of the Otis Lennon School Ability Test, 7th Edition, measures a student's potential for learning. This tool was used by the authors of several dissertations discussed in this document.

SAT-9. The Standford Achievement Test, Ninth Edition, was used as a pre- and post-test in several of the studies discussed in Chapter II.

Scientifically Based Research (SBR). According to Feuer and Towne (2006), educational research, while different from the "hard" sciences in many ways, must share some principles of research in order to be of worth. First, the questions being asked should have significance and be empirical in nature. Second, research should be based on accepted and logical theory. Third, the study's methodology, whether it be descriptive, statistical, or some blend thereof, must be appropriate for the data being gathered. A fourth principle of educational research is that it must follow a "coherent chain or reasoning" (p. 27). Fifth, in order to be of value to practitioners, research must be replicable and generalizable to a broader population. Finally, for educational research to be viewed as valid, its purpose, method, and outcomes should be crystalline to those who examine it.

Time on task. The number of minutes that students spend working on an assigned task. In the case of this research, time on task refers to the number of minutes spent using the learning software tools under study.

For the sake of this study, then, SBR refers to dissertations and other studies that show evidence of solid ethical practices based on the tenets of scientific inquiry as outlined above.

Server-based software. The original version of Compass learning software, mounted onto a school district's server, was accessible only when users were logged onto the district's system. Server-based software was used by students in School A.

Socioeconomic status (SES). Low socioeconomic status among students was determined by eligibility for free or reduced lunch.

Student achievement. Student scores on the Pennsylvania System of School Assessment (PSSA) were the primary method by which change in student achievement was measured. Scores on the 4Sight quarterly benchmark assessment aligned to the PSSA, administered by the district, were reviewed as well.

Students with special needs. For this study, students with special needs were learners for whom Individualized Education Plans (IEPs) had been developed. This was generally the result of a specific learning disability.

Technology use. The most advanced stage of technology use, according to Goddard (2000), is one in which teachers embrace technology as a way to expand their students' knowledge and understanding. They develop projects, collaborative activities and other challenges that include computers and the Internet as part of student inquiry and problem-solving. Teachers and students have access to the Internet and to each other both within and outside of the school setting; they have the capacity to plan, practice and prepare projects that expand their understanding of the curriculum beyond the standard texts and chalkboard presentations. In this study, teachers and students in some groups had daily access to laptop computers and the Internet; they were able to take laptops home as needed; they also had school-issued email addresses. Teachers received regular training in areas related to the integration of technology with curricula.

Technology. The second definition of the term "technology," provided by the American Heritage dictionary of the English Language, applies to this study: "Electronic or digital products and systems considered as a group…" (Technology, n.d.). Computers, projectors, cameras, scanners, software, and Internet are included in the technology examined in this study.

Web-based software. The updated version of Compass learning software is available via the Internet. Teachers and students can access Online Software from any Web-accessible portal. In this study, students in Schools B, C, D, and E accessed Compass materials via the online version of Compass learning software.

What Works Clearinghouse (WWC). An agency of the U.S. Department of Education, the WWC analyzes educational technology programs and software solutions according to specific criteria. The results of the analyses are available to end users at http://whatworksclearinghouse.ed.gov.

Delimitations of the Study

This study included fifth grade students in five elementary schools of a large urban school district in central Pennsylvania. While it is home to ten elementary schools, the selection of schools was based on level of access to CompassLearning Odyssey web-based learning software. Based on this process, a clustered sampling method determined which students were identified to participate in the study as members of control or experimental groups.

By virtue of funds provided via a competitive grant award process, the selected schools had participated in the Enhancing Education through Technology (EETT) initiative sponsored by the Pennsylvania Department of Education. Involvement in EETT gave access to wireless laptop technology and professional development support in the integration of technology with instruction to specific classes of students and their teachers.

During the first year of the two-year EETT project, one classroom of students and their teacher, in third, fourth, and fifth grades, received wireless laptops for accessing technology within the classroom; the laptop computers on wireless carts were shared between two classrooms As an example, all children in the third grade classroom might have use of the laptops in the mornings while the same computers were the domain of the fourth grade classroom for the afternoon. During the second year of the project, a second classroom of students and their teacher, at the same grade levels as above, joined the cadre of EETT participants; at this time, each laptop was shared by four classrooms.

All participating classrooms had been asked to use the software according to the developer's recommendation. This meant that CompassLearning Odyssey would be used a minimum of 90 minutes per week. Students in EETT-supported classrooms had extensive access to technology throughout the day while students in other participating classrooms were limited to using computers during regularly scheduled times in the computer labs. To control for such external factors as differences in teacher training and exposure to the laptops and differences between EETT participants and other classrooms of students in the schools used in the study, classrooms of students, selected by virtue of clustered sampling, were assigned to either experimental or control groups. This was accomplished by the following process: if a classroom of students was assigned to the experimental group for language arts, learners were permitted to use CompassLearning Odyssey for any subject area except mathematics; in this way, these students served as the control group for the students in the mathematics experimental group. Conversely, students in the experimental group for mathematics could use CompassLearning Odyssey in any area except language arts; these students were the control group for the language arts experimental group.

Scores from participating students' third grade PSSA were used as baseline data for the study. Usage data (time spent using CompassLearning Odyssey) from the 2005-06 school years were used for this study. Additional data included scores on CompassLearning Odyssey pre- and post-tests and 4Sight scores.

Limitations of the Study

While the design of the study is reflective of Rand's description, it is limited in scope. Until results of this study are compared to others that take place in a variety of geographic, socio-economic, and cultural settings, findings may not be successfully generalized to other populations.

Gender, SES, identification as learners with special needs, and previous achievement levels were explored in this study as some of the variables that may influence the effect of technology on achievement. These are only some of several areas that may or may not show evidence of differential response to technology as an instructional tool. Students of diverse cultural backgrounds, and students in specific age/grade levels, are some of the additional subgroups that can be explored in future studies of the effect of technology on student achievement. It is worthwhile to note that each of these categories works in conjunction with the others; separating such factors, and accounting for differences therein, was not part of this study.

Teacher attitude and feelings of self-efficacy toward technology are factors that directly influence both the amount of time devoted to, and the level of involvement with, technology in the classroom (Goddard, 2002; Snider, 2002). This issue is not addressed in this study; some of the effects of technology on student achievement may be directly or indirectly impacted by teacher attitude toward using technology as an integrated part of instruction.

Of significance to this study was the change in the evaluation requirements between the first and second year of the EETT project. The experimental and control groups, based on input from PDE, were established at the start of Year Two. Because this was not the original framework of the project, all students were exposed to both language arts and mathematics components of CompassLearning Odyssey. As a result of this condition, this study will report on the rate of growth during the 2005-06 school year.

Chapter Summary

This study hopes to shed light on the benefits of using a specific language arts and mathematics software program as an integrated part of daily instruction. Doing so will add to the body of knowledge about the value of this product as a teaching and learning tool. The benefits of such use will be evidenced by a comparison of the PSSA scores of fifth grade students that are part of either control or experimental groups in a

Pennsylvania school district. The study will also highlight any achievement differences based on gender, SES, identification as students with special needs, and previous achievement levels as a means of determining the circumstances under which such software applications influence student achievement.

To support the need for continued research into the efficacy of specific educational software, the next chapter will present a review of literature in the area of technology in education. While the breadth of such a topic is extensive, the review will focus primarily on language arts and mathematics software in the elementary setting.

CHAPTER II

REVIEW OF THE LITERATURE

As the tide shifts, from a push during the Clinton administration to put a computer into every classroom in the United States (Goddard, 2002; Shields & Behrman, 2000), to a critical evaluation of technology in 2004 as not helping to solve the problem of declining achievement scores (Norris, Sullivan, Poirot, & Soloway, 2003), and to a concurrent reluctance to fund technology in education (Murray, 2004), it becomes necessary to evaluate the overall effectiveness of technology and other programs (Schneiderman, 2004). Having discussed the need for more clearly identifying the elements of educational technology that have a positive influence on student achievement, this chapter will focus on several additional issues related to the use of technology in education.

Because the evolution of technology in classrooms provides a foundation for understanding current trends, discussion will begin with a brief history of technology and its integration into curricular practices. Then, in order to provide a framework for technology in the classroom within the context of established educational theories, the relationship between technology in education and theories of education will be explored.

Recent studies that examine the impact of technology on student outcomes will be included in this chapter. With the accountability issues brought to bear by the NCLB Act of 2001, the relationship between computer use and achievement scores on state-mandated assessments will be of particular interest.

This research will add to current studies that have examined achievement differences between male and female students, students identified as having special needs, student with low SES, and students of varying scores on the PSSA in Grade Three. Discussion will include current trends in the use of technology as part of daily instruction. The limitations of existing studies, as they relate to the current study, will also be discussed.

Following the brief history of technology in education will be a discussion of current trends in the integration of technology with daily instruction and the factors that influence integration. Such elements as professional development, school and home support, and accessibility influence integration (Himes, Pugach, & Staples, 2005; Shuldman, 2004); for this reason, this chapter will detail studies that address the relationship between technology use and student outcomes.

Brief History of Technology in Education

Educational historians like Molnar (1997) often report that the incorporation of technology into classrooms was more the result of an "accidental revolution" than of a deliberate plan. But, since one of the primary functions of education is to transfer the culture and practices of a society to its youth (Ornstein & Hunkins, 1998; Rogoff, 2003), the explosion of technology in business and homes across the country and around the world has made its infusion into the educational realm almost inevitable. Since 1959, when Donald Bitier developed the PLATO reading program for use with undergraduates and elementary schoolchildren (Molnar, 1997), computers have taken on varying roles in the education of children. According to Molnar, four factors have influenced the way in which technology has become a part of students' everyday experience: the move from a localized to a global economy, the information explosion brought about by the World Wide Web, the mandate for accountability toward increasingly strident standards of achievement, and the shift in educational theory from theories of learning ('how students learn') to cognitive theories ('how students think') (p. 64).

Computers in Schools: The Early Years

In the first half of the 20th century, the delivery of education was based on the needs of people as they entered the work force (Goddard, 2002). For the most part, expectations—and opportunities—for schooling were limited to the non-working upper classes. As a consequence, in 1900, the high school graduation rate among 17-year-olds was less than 7% (Cross, 2004). Within this framework, only those people interested in politics or higher learning were exposed to ideas within an educational setting. According to Molnar (1997), four events shaped the role of technology in education. First was the growth of a global economy. Radio, television, and two World Wars led to increased levels of interaction between nations around the world. Second was the explosion of scientific understanding. With the need to know how to retrieve what is known almost overshadowing the fundamental need to know, technology has become an essential part of gaining and using information.

As computers were coming of age in the private sector, they were capturing the attention of educators. Technology was seen as the ideal platform for providing information, on an international scale, to learners in new and engaging ways. The third event in the integration of technology with education, according to Molnar (1997), was the acceptance of theories of cognitive science among educational stakeholders. Around the middle of the twentieth century, the theories of such notables as John Dewey, Erik Erikson, and Lev Vygotsky gained recognition and the act of learning was seen as being native and necessary to human nature (Ornstein & Hunkins, 1998). This change in perspective, coupled with the expanding vistas provided by an increasingly global society, led to the view that world knowledge was critical to the development of every learner. As they became smaller and more adaptable to school functions, computers were seen as the harbinger of universal knowledge for every student.

Molnar's account of the fourth influence on the assimilation of technology into education involves the changing demands by the public about what children should be able to know and do when they reach adulthood. As Cross (2003) points out, the increased role of politicians and the federal government in educational funding gave these entities certain liberties in the formation of educational agendas. As education has become a political forum for candidates and lawmakers, teachers, students, and entire school districts are expected to perform to specific standards. In this environment, the power of technology to provide instruction and remediation, to generate reports, and to track data have made computers an almost essential part of current educational practices. As beneficial as they are, these applications reflect a departure from the belief in the 1970s that computers would be used to transform teaching and learning; early thought was that technology would facilitate participants in constructing their own knowledge and exploring beyond the parameters of the classroom.

Computers in Schools: Current Practices

It is the latter two elements of Molnar's discussion that are addressed in this study. Events after 1980 have not led to diminished integration of technology and education. Rather, they have shaped the current direction for technology as it supports teaching and learning.

In the 1970s and early 1980s, the allure of technology in education was its inherent potential to provide students with opportunities to gain deeper understanding of their place in a complex world. At almost the same time, the oft-referenced 'Sputnik' issue arose (Molnar, 1997) wherein U.S. politicians feared that other nations were gaining on America’s scientific and academic superiority. As then-President Reagan sounded the alarm that the academic performance of American children was falling behind that of children in other countries (National Commission on Excellence in Education, 1983), and echoes reverberated through both George Bush administrations, the purpose of technology in education changed. Instead of being the medium that would allow learners to participate in a global forum of shared ideas, computers became tools for fine-tuning and digitizing learning into fact-based fragments of information. With added pressure to show achievement gains on state-mandated assessments, states and schools assigned increasing value to measurable fact-based learning. Technology became a medium for teaching and reinforcing the acquisition of information. Schools used computers to teach and to track individual and group performance on assessments aligned to state standards of learning. Technology was the medium by which educators and government agencies could monitor and compare learning among groups of students across schools, districts, and states. With computers, educators could get detailed feedback about student progress toward mandated educational goals.

While the ways in which computers are used have evolved as political tides ebb and flow (Groundwater-Smith, 2004), the overriding goal of technology in education has been the enhancement of student achievement, regardless of the mode of implementation and despite the fact that the definition of the term 'student achievement' changes.

Computers became more firmly entrenched in American education when the Goals 2000: Educate America Act (1994) set the blueprint for states to encourage the integration of technology with curriculum. According to Shields and Behrman (2000), nearly every school is equipped with computers and Internet access.

Computers and Children: Issues of Access

In addition to the fact that almost every school in America is equipped with computers and Internet accessibility, computers are in more than two thirds of American homes (Digest of Education Statistics, 2004). Concern remains, despite access to computers in schools, that access to technology is limited in scope and that the more at-risk groups of learners have less access to technology than do other groups, particularly at home (Norris, Sullivan, Poirot, & Soloway, 2003). In a 2004 data file, the U.S. Department of Commerce reported that, of households that use computers in the home, 36.9% are White non-Hispanic, 15.6% are Black, non-Hispanic, and 14.5 are Hispanic (34.8% of U.S. households with computers fall into an "Other" category). Many educators and researchers point to this statistic as evidence that, in order to support disadvantaged groups, schools ought to provide equitable access to technology during the school day.

Access alone does not level the playing field for disadvantaged groups of children. While almost all U.S. public schools are equipped with access to the Internet and other technologies, evidence shows that the ways in which computers are used vary between schools based on the SES levels of their clientele. Becker (2002) notes that teachers and learners in disadvantaged schools use computers more frequently than do members of schools that serve non-disadvantaged children. This use, however, is of a tutorial/remedial nature; teachers and learners in schools that serve non-disadvantaged students tend to use computers in more constructivist ways: expanding on ideas and creating projects. In one example, kindergarten children who participated in a technology-based early literacy project showed greater use of computers in ways that mirrored the constructivist process described above (Tracey & Young, 2006). The result of specific training and support, this project demonstrates the potential of computers in schools—if used appropriately—to offset the disadvantages of limited home access to technology.

Computers and Teachers: Issues of Implementation

Dialogue about the history of computers in schools must include conversation about the attendant concerns that have surfaced as technology has become increasingly embedded in educational processes. In addition to issues of access, the extent to which public school teachers use computers can vary as a result of their comfort levels or feelings of expertise as implementers of technology; this in itself leads to differences in technology use among groups of students. Means (1994) describes technology integration in terms of its function: at an entry level, computers are often used as a tool for tutoring and communicating; a more sophisticated use of computers provides opportunity for exploration and creativity.

Availability and training opportunities for teachers are just two factors that can affect the ability of children to effectively use technology as an integrated learning tool. As referenced earlier, student factors can also impact the ability of technology to have maximum impact on achievement. For example, researchers are noting disparity in the effect of computer-aided instruction on children based on gender and socioeconomic status (Jarrell, 2000; Newcombe, 2005; Palmer, 2001; Rose, 1997). It is necessary to recall these issues when discussing the ability of computers to positively impact student achievement.

The Relationship between Computers in Schools and Theories of Education

As mentioned earlier, the use of technology in education is supported by more than one of the major educational theorists of this age. The recommendations of Skinner, Piaget, Vygotsky, Bandura, and Wiggins, representing ideas ranging from behaviorism to constructivism, are evidenced in current technology-education integration practices. This section will review the use of educational software as it relates to behavioral, cognitive, and constructivist learning theories.

Computers in Schools and Behavioral Learning Theory

Behaviorism is as much a part of American public education as reading, writing and arithmetic. Behavioral theories of education involve controlling the school environment in order to train the learner to respond in specific ways. B. F. Skinner's work in programmed instruction, involving positive reinforcement and stimulus withdrawal, can be seen in most forms of programmed educational software (Baker & O’Neil, 1994). Much educational software is designed to respond to input provided by the learner, who is in turn provided such secondary or generalized reinforcements as the ability to move to the next activity, a scored report, or even an onscreen congratulatory note.

CompassLearning Odyssey software, the target of this study, is no exception. When working through a sequence of learning activities, students are given verbal or onscreen messages like “Good Job!” and “Congratulations!” Student behavior is further managed by the software in that learners are prevented from progressing through lessons unless they provide correct responses to questions along the way.

Another behaviorist, Albert Bandura focused his attention on modifying aggressive behavior through repeated observation and modeling. Transferred to the academic realm, Bandura's route to learning relies on two elements: attention to the task at hand (instruction) and evidence of the ability to demonstrate understanding by repeating the skill that had been modeled. The goal of Interactive Computer Technology (ICT) is to offer students appealing ways to participate in their own learning and to reteach skills as often as needed in order to ensure that students are able to correctly respond to questions at the end of each skill set. Engagement and repetition are two of ICT's greatest strengths (Laffey, Espinosa, Moore, and Lodree, 2003). Engaging learning software, according to Bandura's theory, is likely to foster achievement gains because it provides opportunity for repeated practice with appropriately modeled instruction.

The contribution to behaviorist learning theory made by Robert Gagné was that of hierarchical learning (Ornstein & Hunkins, 1998). With eight categories of learning, each building in sophistication on the previous category, this theory is a bridge between behavioral and cognitive learning theories. Gagné developed a theory that ranged from a beginning learning process (signaling for a correct response), which can be identified as being purely behavioral in nature, to a more mature learning style (problem solving) that is characteristically cognitive. According to Gagné (1987), "structured knowledge facilitates problem-solving" (p. 69). The properties of learning software lend themselves to the presentation of information and learning tasks in a controlled, student-directed way, allowing for the structured knowledge referenced by Gagné.

The ability of educational software to provide both root practice with specific responses to input and to support higher levels of understanding leads to the need to explore its place in cognitive theories of learning. The next section will examine the levels to which learning software reflects cognitive learning theory.

Computers in Schools and Cognitive Learning Theory

Because it progresses in stages from behavioral to cognitive constructs of learning, Gagné's model of the way people learn can be viewed as a bridge between behavioral and cognitive learning theories. Pure behaviorism espouses a teacher-controlled environment in which students gain specific pieces of understanding in a sequenced manner. Cognitivism, on the other hand, is concerned with the developmental stages of learning. Students are ready to grasp, analyze and synthesize progressively more complex concepts as they build on previous experiences. Cognitive theorists suggest that because the experiences of every person vary from those of others, learners internalize and interpret information differently and in highly personal ways.

Interactive Computer Technology (ICT) is a term used to define software designed to provide varying input based on a student's responses to items as they are presented. With ITC, students themselves determine the path along which the program travels as it guides them to the desired learning outcomes. Definitions of ICT often reflect McCormack's (2002) statement that "… computer-based technology allows learners … to take an active participation in their own learning process" (p. 1151). ICT is often a mainstay in educational technology programs in that, after the initial screen, ensuing instructions and modules are the direct result of the student's earlier input. Following the theory of scaffolded instruction as described by Vygotsky (Laffey, Espinosa, Moore, &

Lodree, 2003), this process helps students gain understanding of increasingly complex ideas without allowing them to miss important concepts along the way. Laffey, Espinosa, Moore, and Lodree (2003) point to the fact that the scaffolding seen in computer programming has the advantage of never tiring of the repetition that leads to “habits of mind and attributions of success” (p.424).

Similar to scaffolding, the theory of hierarchical learning as explored by Gagne’ (Ornstein & Hunkins, 1998) is supported by ICT. Byers and Byers (1998) describe hierarchical learning theory as the understanding that new knowledge is possible when it is supported by the previously learned foundational knowledge necessary to support higher levels of understanding in a given area of study. Further, the learner’s knowledge at the start of instruction is critical in determining the point at which instruction should begin.

Software programs, particularly those designed by grade level, contain elements reflective of the developmental stages of targeted users. Easily evident in mathematical applications, these educational programs are quite similar to textbook designs that present material in graduated degrees of complexity to teach concepts like fractions, multiplication, etc.

Educational software, including the Odyssey product targeted in this study, supports hierarchical learning theory in that, after their initial interaction with the program, students’ subsequent lessons consist of activities specific to gaps in understanding.

Computers in Schools and Constructivist Learning Theory

There is some argument about the fit between constructivist theory and technology in education. Critics of the claim that technology supports constructivist-style learning feel that, since computers do not give learners direct contact with the objects of their learning (e.g., touching and counting blocks as opposed to manipulating simulated blocks on a screen), technology, as a means to learning, cannot be viewed as being inherently constructivist in nature (Gance, 2002). However, according to some educational theorists, Piaget’s view of learning as being the result of one’s experiences does include one’s experiences with technology (Boudourides 2003; Verillon, 2001).

Duffy and Jonasson (1992), maintain that it is in the design and the implementation of technology that constructivist attitudes toward learning can be seen. As an example, Hirumi (2002) developed a model for operationalizing constructivist learning objectives. Intended to enhance computer independence and competence among undergraduate students, the program design, while following the step-by-step process of traditional instruction, led to outcomes most akin to the goals of a constructivist educational plan.

In the early 1990s Scott, Cole and Engel (1992) found that students who used computers as tools for learning were more willing to take the initiative in seeking new knowledge; rather than teaching in traditionally didactic ways, teachers facilitated students in their quest for solutions to challenges.

Boudourides (2003) distinguishes between philosophical, cybernetic, educational, and sociological applications of constructivist theory. The latter two have a discernible relationship with technology as a learning tool. A socio-constructivist influence can be seen in applications of computers in education when students engage in collaboration, exploration, or critical evaluation of current thoughts and practices. (Boudourides, 2003).

While some concerns exist that using a computer is an isolationist activity, others argue that they provide a forum for community within a localized classroom and across the globe (Boudourides, 2002; Duffy & Jonassen, 1992; Scott, Cole, & Engel, 2002).

Technology has the potential to help educators "teach to big ideas" as promoted by Grant Wiggins (Wiggins & McTighe). Cross-curricular projects and collaborative activities, between groups of students anywhere in the world via the Internet, make such processes feasible in the face of increased demands on time for objective, standards-based learning modules. CompassLearning Odyssey software, however, does not directly include this form of exploration in its recommended processes. As students proceed through learning modules, they are offered resources for further exploration.

CompassLearning Odyssey software is not designed to measure or evaluate such exploration directly. As many theorists believe, however, extension activities, while not a measured part of the software, would be likely to impact a student's performance of the tasks imbedded in the evaluative piece of the software.

Computers in Schools and Theories of Social Capital

The term “social capital,” according to all sources on the subject, was first coined by Lyda Judson Hanison, a Progressive educator of the early twentieth century. He used the phrase to describe the degree to which individuals gain strength as members of a community. Hanison explained that the social capital of an entire community is enhanced by the interaction of its members. Putnam (2004) reflects this concept when he states that social capital is enhanced when members of a society share common aspirations and when each views others as equals.

Hall (2004) speaks to the “distributive dimension of social capital” (p. 55). Public schools, as discussed by Hanison and Putnam (2004), are conduits to the equalization of social capital among individuals. And, according to Cuban (2001), technology has the power to add to the social capital of members of a school system—and to entire communities—by leveling the playing field for participants.

While he acknowledges the *potential* inherent in technology to support healthy gains in social capital for students, Cuban hastens to add that, “Without a critical examination of the assumptions of techno-promoters, a return to the historic civic and social mission of schooling in America, and a rebuilding of social capital in our schools, our passion for school-based technology, driven by dreams of increased economic productivity and the demands of the workplace, will remain an expensive, narrowly conceived innovation” (p 196). Given the current use of technology, Cuban believes that, instead of promoting improved civic and social goals among participants, technology is not a worthwhile expenditure.

While this dissertation does not directly address social capital as a focus for study, it is reasonable to infer that, if CompassLearning Odyssey computer software equalizes achievement between groups of learners, technology in this case will have supported the expansion of social capital for participants.

The Evolution of Research in Educational Technology

The value of this study is its ability to contribute to the currently limited body of knowledge that objectively evaluates the educational software purchased by schools across the United States. After providing background about the need for studies of learning software, this section will discuss studies related to specific software interventions and their effectiveness in improving the reading and mathematics scores of students on standardized assessments. Material will be categorized according to the type of program (language arts and/or mathematics) being studied and the context in which it is being examined.

The Need for Studies of Learning Software

Historically, few studies had been done that have used rigorous, objective research methods to measure the effectiveness of technology as an educational tool (Bailey, 2004). Prior to NCLB, it had been common for school districts to rely on data provided by the software developers as evidence of a program's efficacy. As a consequence, there exists a need to verify that specific learning software programs lead to achievement gains in targeted areas. Budgetary constraints experienced by school districts, coupled with a concurrent need to show positive growth in the reading, writing, and mathematics achievement of all students, have led schools to examine all aspects of instruction in order to expend time and money on only proven programs and tools. It has become necessary for schools to justify the use of computers—not in terms of student satisfaction or staying current with societal expectations—by the measurable gains they can deliver on state and national standardized assessments.

To address this issue, the Department of Education attached a program evaluation requirement to the technology funding provided in the Enhancing Education Through Technology Act of 2001 competitive grant process. Item Number Seven of Section 2402(a) stated that the purpose of the grant was "to support the rigorous evaluation of programs funded under this part, particularly regarding the impact of such programs on student academic achievement, and ensure that timely information on the results of such evaluations is widely accessible through electronic means" (U.S. Department of Education, 2002b). Districts that received EETT funding were required to evaluate the effectiveness of the funded program; this evaluation included a description of the software and its contribution to improvements in student achievement.

The goal of the evaluation requirement was to identify successful technology implementation practices, encourage the adoption of similar programs in other districts, and avoid the pitfall of expending resources on less-than-successful programs. The EETT requirements included the evaluation of software effectiveness, professional development strategies, and gains in student achievement as they related to district-specific projects. There was no requirement for reporting outcomes according to a predetermined set of criteria. Within this context, then, there was limited opportunity to compare learning software in standardized ways.

Another issue that led to limited use of the evaluation component of EETT projects was the manner in which funding was awarded for the second and third years of the grant. Districts whose end-of-year reports showed appropriate gains were likely to receive additional funding. Under these circumstances, school districts were careful to evaluate their programs according to criteria that showed them in the best light: reports of moderate or negligible gains in student achievement or software effectiveness were at times cushioned by more impressive data that showed improvements in professional development, teacher attitude toward technology, or other areas of the projects.

In 2002, the U.S. Department of Education earmarked $56 million for state-sponsored studies across the country (U.S. Department of Education, 2002a). The goal of these studies was to develop methods for evaluating technology. While the studies were research-based in nature, this initiative neither directly addressed the effectiveness of specific software products nor provided accessible information to end users of educational software. However, the process marked the establishment of several efforts to provide such a resource. Discussed in the next sections, they offer usable information to entities interested in locating reliable information about effective technology-related educational products and processes. These resources make it possible for schools and other entities to bypass previously tried—and ineffective—programs in favor of those that offer true promise in meeting goals.

The What Works Clearinghouse

The assumption behind the move toward scientifically based research (SBR) in education is that viable programs will be identified and made available to schools nationwide. The next development in the establishment of a means for providing a central resource for locating scientifically proven studies of technology in education was the What Works Clearinghouse (U.S. Department of Education, n.d.), an extension of the Department of Education's Institute of Education Sciences. Initiated in 2002, this agency evaluates studies and programs according to a predetermined set of criteria. Of the seven areas currently under study by the WWC, two are germane to this study: curriculum-based interventions for increasing mathematics achievement among elementary school students and interventions for beginning reading. Other areas under study at the WWC include programs for English language learners, mathematics for middle school students, character education programs, school readiness programs, and dropout prevention programs. School districts with an interest in initiating programs to address any of these needs can look to the WWC for studies that examine the effectiveness of related projects and programs.

According to Cuban (1986), the practice of maintaining and evaluating the success of an innovation after two or fewer years is a key reason for the fact that technology has not yet been "proven" effective in enhancing student achievement. One of the WWC's greatest contributions to educational research may be its ability to provide a longitudinal view of similar processes, thus expanding the knowledge base of educational researchers.

The WWC does not pass judgment on software or on implementation processes. Rather, its focus is on the studies that examine the efficacy of software and processes. The WWC uses specific criteria to determine the overall strength of interventions to assign one of three ratings to examined studies: "Meets Evidence Screens," "Meets Evidence Screens with Reservations," and "Does Not Meet Evidence Screens" (U.S. Department of Education, Institute of Education Sciences, n.d.).

The WWC is a government sponsored resource available to all site visitors. Other web sites perform similar services, although a fee is sometimes involved. An example of relevance to this study is the Metiri Group, a private organization that was retained by Pennsylvania's Department of Education to support and evaluate the progress of the state's EETT grant recipients. The next section will discuss the role of the Metiri group in fostering rigorous and research-based studies of technology interventions.

The Metiri Group

Ed Coughlin, senior vice president of the Metiri Group, states that, prior to recent years and through the efforts of the What Works Clearinghouse and similar organizations, the primary source of research into the effectiveness of specific software programs was the product manufacturers. For this reason, the validity of the results of such research was at times "suspect" (personal communication, March 14, 2005).

The Metiri Group is an independent firm that has partnered with the U.S. Department of Education, the State Education Technology Directors Association (SETDA), the Pennsylvania Department of Education and others to provide research assistance, product evaluations and technology integration support to educational entities (Metiri Group, 2006). The role of this organization is significant to this study because the Metiri Group was the evaluator designated by Pennsylvania's Department of Education to work with the state's EETT grant recipients to modify their projects in order to include more research-based methodologies in their program delivery and evaluation procedures. The Metiri Group had worked with the school district involved in this study in 2004; it is for this reason that meaningful and usable data were available for the research that will be discussed in this dissertation.

Having established the background for current efforts at legitimizing studies of educational software, the following sections will explore the impact of computers on student achievement as evidenced by recent research that relate to the study at hand.

Research in Educational Technology

A review of literature shows that studies of technology software fall into general categories based on characteristics. Some studies are descriptive in nature, explaining the ways in which computers are used, the attitudes and perceptions of users, or the effects of computer use on other aspects of education.

More pertinent to the study at hand, other studies attempt to explain causality. By comparing outcomes in specific domains (e.g., attitude, achievement, frequency of use), researchers hope to provide evidence that can be used to promote desired outcomes among learners, teachers, and others involved in the educational process. It is research in this latter category that will be examined in this section. In order to provide an appropriate framework for the current study, exploration will include research that involves educational software interventions in language arts and mathematics. While some discussion will include work with middle or high school students, the bulk of studies will focus on elementary-aged children. Particular attention is paid to studies that explore variation in the effect that computer software interventions have on achievement based on the categories outlined in the current study: SES, gender, identification as students with specific learning disabilities, and previous achievement scores.

Although a limited number of early studies explored the effectiveness of Jostens Learning educational software (a predecessor of CompassLearning Odyssey), the review of literature revealed a dearth of studies directly related to CompassLearning Odyssey language arts or mathematics software. While validating the need for the present study, it is necessary to explore the effect of Jostens Learning and other brands of educational software whose aims are to support student achievement in ways similar to the goals of CompassLearning Odyssey.

Studies of Technology in Education: Language Arts and Mathematics

Because of their relevance to this dissertation, the articles and studies in this section pertain to student achievement in reading and mathematics. Current research on the impact of technology on language arts and mathematics achievement, while relatively sparse, tends to focus more on elements of language than on mathematics. The majority of the articles and studies examined focused solely on elements of language (reading, writing, or vocabulary); the others six studied either mathematics or both language arts and mathematics achievement. Not all of the research related to a specific intervention but, in all cases, student gains in various forms were the desired outcomes of the investigations. This discussion will provide an overview of significant studies and the factors found to impact student achievement. The topic of teacher use of technology is not a direct focus of the dissertation at hand; however, it appears to affect outcomes for some students and under particular conditions.

Additional research examines SES, gender, previous achievement levels, and status as students with special needs as factors in the degree to which technology influences student achievement outcome; these attributes are part of the current dissertation and will be highlighted later in this section.

In all of these discussions, the interrelatedness of factors is evident. For example, it is common for a study, whose attention was on the amount of time spent with computers, to reveal that the effect of time on task varied by student demographics. Because crossover is inevitable—and desirable in order to reach conclusions about the circumstances under which computers have the greatest positive effect on learning—some studies will appear in more than one section of this chapter.

Time with Technology

Norris, Sullivan, Poirot, and Sullivan (2003) questioned whether or not the amount of time allotted to computer use affected reading and mathematics achievement outcomes. They found that motivation and test scores improved with increased time on task. In the 48-question "snapshot survey" of teacher behaviors and attitudes, conducted across the United States since 1997, the authors concluded that the potential of technology to significantly increase reading and mathematics scores relates directly to time on task. With limited access in terms of time and training, teacher implementation remains at a level below that needed to have noteworthy impact. With this in mind, the following vignettes will describe studies of technology as it is currently being implemented in classrooms.

The basic premise of Norris, Sullivan, Poirot, and Sullivan (2003) is borne out in a study that examined the influence of experience with computers on the behaviors that lead to achievement gains. Tang-Lau (2004) examined the effects of a simple word processing tool as it was used in student writing activities. Both teachers and administrators reported that the devices led to enhanced computer literacy skills and to better quality in the writing samples produced by students. Their perception was that student engagement with technology over pencil and paper led to increased time on task, greater willingness to proofread and edit work, and to improved self-images as successful writers. Although Tang-Lau's work focused on behaviors more than on measured achievement outcomes, her study supports the belief that the appealing and motivational nature of technology endows it with an inherent capacity to improve student performance in academic areas.

Among studies related specifically to reading achievement, Bogle (2000) compared the level of technology use among students with their reading achievement scores on the Illinois School Achievement Test. His study of elementary students from 1995-1999 showed that, when poverty was equalized, there was no significant correlation between engaged use of technology and reading achievement. However, when SES was considered, an inverse relationship was discovered: measurable gains were seen among students of low SES who had increased engagement with technology as an instructional tool in reading.

In a study of the effect of technology on both mathematics and reading achievement, Plowden (2003) compared archived data from elementary and middle schools. Looking at scores on the Iowa Test of Basic Skills (ITBS) between students in a school that integrated technology with instruction and another school whose teachers and students did not have access to technology as an instructional tool. The author used 1994 data as a baseline because technology was introduced to specific schools in the district after that year. Plowden tracked student scores between technology-infused and non-technology-infused scores from 1995 to 2000.

While both elementary and middle school students in experimental groups showed significant gains, the degree of improvement varied between groups. Among students in the elementary schools, in both reading and mathematics, the scores of students in experimental groups, whose baseline scores had been below those of students in the control groups, increased to a level similar to those in the control groups. Among middle school groups, the reading scores of students in the technology-supported schools surpassed the scores of students in the control groups.

In a similar study, Bohannon (1998) found that frequency of use had varying effects on student mathematics and reading achievement only when specific student characteristics were considered. After examining archived data from 1,754 fifth grade students, Bohannon found that SES and gender influenced the effect that increased time with technology had on their achievement. In this study, the same students were used in both phases of the research. For one semester, they had 1:1 access to computers. Under this condition, boys showed the most significant gains on test scores. During the second semester, however, two students shared access to one computer. Under this condition, the gains of boys were not significant. In both reading and mathematics, the performance change among girls was not statistically significant.

Bohannon cites ethnicity as a factor in the influence of technology on student outcomes in that, in both reading and mathematics, Hispanic males showed significant gains with increased access to computers. However, this information is coupled with Bohannon's finding that students of low SES (and concurrent limited home access to computers) showed greater gains in both mathematics and reading with increased school access to computers. Given the fact that, in the U. S., Hispanics are statistically more likely to live in poverty, more information is needed in order to make the assumption that it is ethnicity and not SES that leads to this condition of learning for this subgroup. Related to ethnicity and time with technology, Perez (1997) found that, among groups of students in classes of English for Speakers of Other Languages (ESOL), time with technology was a consistent predictor of mathematics and reading gains. SES and gender were also significant influencers of improvement in both areas. This finding supports the infusion of computers into daily instruction. As will be discussed at greater length later, SES appears to be a common denominator in the interplay of multiple factors that affect the impact of computers as instructional tools.

Another study by Jarrell (2000) supports Bohannon's observation that time with technology has varying effects on student achievement. In this study, sixth and seventh grade students had unlimited one-to-one access to computers for one semester; for the second semester, the ratio of students to computers was 2:1. Jarrell studied the rate of reading achievement gains between semesters. The author did not compare the gains of these groups with other groups without technology; however, he notes marked achievement differences based on gender. Achievement gains were significantly less among males with unlimited access to computers than they were among males with limited access. While one might point to first- versus second-semester variations in scores as being the result of familiarity with the programs, this development is juxtaposed with the fact that girls did significantly better with limited access in the second semester than they did with one-to-one access during the first semester.

Although the physical availability of technology in the classroom has a direct effect on student use, there is evidence that teacher behaviors directly affect the use of available technology. The next section will explore studies that examined student achievement with technology as it is impacted by teacher implementation and attitudes.

Teacher Use of Technology

"…wiring schools, buying vast amounts of hardware and software, and campaigning to encourage teachers to use new technologies in their classrooms have produced a modest shift from nonusers to occasional users and from occasional users to serious ones" (Cuban, 2001, p. 71). This circumstance of only moderate changes in teacher demeanor toward technology over time—and after great investment—has led researchers to study the frequency of technology use by teachers. As related to this dissertation, discussion in this area will highlight research that correlates such teacher behaviors with student achievement outcomes.

Time with technology can be examined from the perspective of students or teachers. While they are inextricably intertwined, researchers have an interest in discerning the impact of each on student learning. Karpyn (2003) measured the level of use by students and teachers as predictors of achievement. She reported on outcomes between groups of students based on geographic location, pupil/teacher ratio, and SES. Karpyn found that, in all areas except reading, levels of student use outweighed levels of teacher use as predictors of achievement; in reading, increased time with technology by teachers made a difference in student scores. However, she also noted that teacher use of technology has progressively less direct impact on student outcomes as students advanced in grade levels. Of further interest is Karpyn's observation that SES has a greater effect on computer use combined than does geographic location or student-to-teacher ratio.

Howery (2001) found a relationship between teacher training and time on task with computers. She compared two classrooms equipped with similar technologies. The teacher in one classroom received training in the implementation of technology in instruction while the teacher in the second classroom did not receive training. Student scores on the SAT-9 were used as pre- and post-tests to gauge the impact of technology on student achievement. Howery's analysis of teacher use showed significantly more frequency of technology use in the first classroom than in the second classroom. While it is important to note that other factors may have influenced outcomes, the SAT-9 post-test scores of students in the classroom whose teacher had been trained in the use of the classroom's technologies were higher than those of students in the alternate setting.

Related to Howery's work, FitzPatrick (2001) studied the effect of technology-rich instruction versus traditional instruction in two mathematics classes taught by the same individual. Unlike Howery, FitzPatrick did not focus on student outcomes; she was interested in knowing whether or not the infusion of technology altered the teacher's delivery mode after time. Using semester-long observations, individual and focus group interviews, FitzPatrick concluded that the teacher used technology in ways that supported rather than supplanted traditional teaching methods. However, FitzPatrick noted that the teacher's use of the new technology was more innovative at the start of the project than it was at the end. The author attributes this trend to limited administrative and training support throughout the semester. While FitzPatrick's work does not address student achievement outcomes, her study points to a recurring theme regarding the reasons for sometimes less-than-expected gains shown by students after the introduction of technology to the learning environment: consistent levels of training, access, and administrative support are required in order to realize its potential for improving student performance.

As research suggests (Kadel, 2005; Middleton & Murray, 1999), teacher attitudes toward computers as an educational tool have a direct bearing on the success of technology in supporting gains in student achievement. Just as FitzPatrick attempted to show the relationship between teacher preparedness and student achievement, Washington (2003) studied the impact of teacher perceptions of technology's effectiveness as it related to student achievement. Working with twenty elementary teachers, interviews and reflective writings revealed that, over time, maintaining support and expectations for the use of a specific early reading program added to positive teacher perceptions of its value. Similar to other studies, while not directly tied to student achievement, Washington's findings have direct bearing on strategies and processes that lead to achievement gains in a technology-rich environment.

Related to the influence of teacher attitude toward computers on student outcomes, Barnett (2006) investigated the effect of a computerized reading program on the reading and fluency skills of emergent kindergarten readers. Half of all kindergarten classes in a Florida school district used the software as a supplement to regular instruction while the other half maintained traditional instructional methods. Skills were broken down to letter naming, phoneme segmentation, nonsense word decoding, and initial sound fluency. Barnett found no significant difference in any area except initial sound fluency; in this case, scores were actually lower for experimental groups than for control groups. English Language Learners (ELLs) in experimental groups, however, showed significantly better ability to identify initial sounds and name letters. Students identified with special needs showed no greater growth than did those in control groups. Even as student gains were not evident for the duration of this study, measurable improvement in teacher attitudes toward the software were noted by the end of the study. Given the fact that teacher beliefs affect a program's efficacy, as discussed earlier, it is possible that further or extended study would yield more positive results.

A study by Buchanan (2003) involved fifth grade students in 100 elementary schools. Buchanan's primary questions sought to determine the existence of a relationship between Internet access, the number of computers in a classroom, and the availability of computers in the home, and student achievement. After analysis of data, she found that none of the factors identified above impacted student achievement.

Instead, an item related to the level of teacher integration of technology in the classroom yielded the only statistically significant outcome. Students in classrooms whose teachers were successful integrators of technology, as identified by building principals, showed achievement gains over students in classrooms whose teachers were less inclined to promote technology use in daily activities. Given the fact that Buchanan's conclusions are the result of principal perceptions, other factors such as favoritism and the administrators' own perceptions of appropriate technology integration may influence the results of the study. Further exploration in this area might yield valuable insight into the elements of the learning environment that promote effective use of technology.

In a similar study, Chung (2002) found that the ways in which teachers use technology affected student outcomes. Access being equal, level of implementation by teachers led to improved scores in reading and mathematics. Chung also found that increased access to computers had a positive impact on students of low SES; high levels of access to computers in school did not have a significant effect on the scores of students of average or high SES. Chung noted that greater gains were evident in mathematics scores than in reading scores.

A study by Fields (2004) calls attention to the need for close examination of a study's results before drawing conclusions. Fields' work focused on advanced levels of experience and training among teachers and their impact on student achievement. Fields examined years of teaching experience and number of degrees or certifications as indicators of implementation. The author concluded that teachers with more experience and more degrees actually used technology less frequently than did teachers with fewer years of experience and with fewer degrees or certifications. Of interest here is the fact that little reference was made to the fact that years' experience and the acquisition of advanced degrees are tied to the age of teachers. The insignificance of the age of participants is reflected in other research that shows little age-related difference in technology integration or levels of concern in using technology (Atkins & Vasu, 2000).

Studies of Technology in Education: Outcome Differences based on Gender

While his focus was on outcome differences based on time spent with computers, Jarrell's 2000 study, discussed earlier, points to gender as being a factor that influences the effect that time with technology has on student achievement. The area of primary interest in this section is the effect of gender on achievement after technology is integrated with daily instruction.

Rose (1997) studied 590 fifth grade students who had used Jostens learning software as a part of their regular language arts instruction. Jostens is the product that preceded CompassLearning Odyssey educational software; for this reason, program delivery and content are similar to the CompassLearning Odyssey product. Rose found that gender alone led to no significant difference in language arts achievement (comprehension, vocabulary, and total reading achievement). However, he also noted that gender, when correlated with SES, did lead to significant differences between experimental and control groups. Male students of low SES showed fewer gains than did female students of low SES.

Research by Connolly (2005) showed additional gender-based differences in the impact of technology on achievement. As Connolly's work focused specifically on perceptions and choices in the area of computer use, her study pointed to sociological influences on noted differences. While girls spent more time on computers at home than did boys, male students more frequently gravitated toward computers at school than did girls. However, when the teacher imposed a time limit on use, and computers were not dominated by boys, girls willingly spent more time using computers. Among Connolly's conclusions was the fact that second grade girls defer to boys when it comes to claiming time with computers in the classroom. Although her study does not directly examine student achievement, Connolly's findings may shed light on gender differences in computer-based achievement differences between male and female students.

Studies of Technology in Education: Outcome Differences based on SES and Identification as Students with Special Needs

While socioeconomic status and identification as learners with special needs are separate categories, it is common for students with IEPs to qualify for free or reduced lunch. For example, the U. S. Department of Education (1996) reported that, in inner city schools, 90% of students with special needs were beneficiaries of some amount of public assistance. Citing several resources, the same report states that "poverty levels may affect the need for educational services, in general, and special education, in particular" (¶3). For this reason, this section will discuss research that focuses on SES and/or status as students with specific learning disabilities.

The term "cultural capital" is used by Palmer (2001) to explore access to technology as an indicator of student performance on tests of computer proficiency. Although the study does not explore achievement gains specifically, Palmer sees social class as a barrier to educational opportunities and relates performance on technology assessments as comparing similarly to performance in achievement. She bases her assumptions on the observation that students of higher SES are more regularly assigned to higher or more educationally rich classes. Palmer notes that students of higher SES generally have greater access to technology at home; to compound the disparity in cultural capital between students of high- and low-SES, exposure to technology at school is more available in advanced classes than in general classes to which student of low socioeconomic status are most likely to be assigned.

Interestingly, after discussing the inequities in cultural capital, as expressed in access to technology, Palmer's research shows that students' attitude toward, and knowledge of, computers had greater influence on scores than did SES, gender, ethnicity, or prior performance on similar tests. This information supports the notion that exposure and use, provided to students that are at-risk in terms of SES, gender, or ethnicity, can help to bridge the achievement gap between these groups and mainstream learners.

Studies of Technology in Education: Outcome Differences based on Previous Achievement Levels

Just as no two human beings are identical in every way, there are vast differences between children in school readiness, ability levels, and rate of knowledge acquisition. With this in mind, when looking for achievement gains, it is desirable to note the achievement levels of students before an intervention is initiated. Some researchers elect to pair students in control and experimental groups based on beginning performance levels; others study pre- and post- test scores of individual students. Both methods lead to data that can be reasonably interpreted to show changes in student performance over time. This section will discuss some recent studies that included previous achievement levels in studies of learning software.

Campbell (2002) compared the achievement gains of children in fourth and fifth grades within a school district. Children in seven schools had access to a technology-based instructional software system; children in the remaining six schools had no CAI. To ensure appropriate comparisons, schools were matched based on the School Ability Index, part of the Otis Lennon School Ability Test, 7th Edition. Overall, no significant gains were evident beyond an isolated pair of schools. While this discovery in itself is worthy of further investigation, the interesting outcome of the study was the fact that students in the treatment schools, who scored in the low or middle range of the SAI, showed consistent gains. This finding is reflective of other studies in which more at-risk populations (e.g., low SES or minority groups) benefit more from technology interventions than do other groups of students.

In a small study, Ritchie (1999) looked at the achievement gains of six high-, six middle-, and six low-scoring students as they participated in a six-week computer intervention program. Pre- and post-tests included standardized reading tests, a basic reading inventory, and reports generated by the software program in use during the intervention. Because achievement naturally improves over time, the fact that students showed growth is of less interest than the rate at which growth occurs and the variation in growth rates between groups. As a way to discern the causes of any differences in the rate of growth between groups over the course of the study, Ritchie included attitude and self-concept surveys and interviews. According to the author, attitude toward the computer program was a significant factor in the rate at which students' scores increased over the six-week period. More than prior achievement levels, positive feelings toward the technology impacted outcomes. Students with few or no negative experiences while using the software program showed greater gains than did students—at any prior achievement level—who reported feelings of frustration with the program. Even high-achieving students, whose initial experiences were positive, showed disappointingly small gains after experiencing problems using the software.

In an attempt to identify the depth of learning that occurs with technology, Mintz (2000) used the SAT-9 and the OLSAT in a study with elementary-age children. Mintz gathered baseline data from both instruments for students in classes that used a specific technology intervention and for students in classes that did not use the software. The author found that, after one year, there was no significant difference in growth in the area of critical thinking as measured by the OLSAT. The one area that showed measurable growth was among students who started the program with high SAT-9 scores. The critical thinking scores were significantly higher for these learners than for learners whose SAT-9 scores had been in the low or middle range.

The preceding discussion makes it easy to see that, even as they shed light on various aspects of teaching and learning with technology, studies affect—and are affected by—myriad elements outside of the studies themselves. The next section will detail some of the problems that arise in the pursuit of understanding the relationship between technology and achievement.

Limitations of Studies Related to the Integration of Technology and Curriculum

Despite the fact that educational research attempts to resolve questions about the ways in which students learn, there are inherent limitations to the power of any one study—or a group of similar studies—to provide irrefutable evidence that proves or disproves specific hypotheses. Sample size, political vacillation, and the malleable nature of elements within a learning environment are just three of the issues that confound efforts to arrive at valid and reliable conclusions. This section discusses some of the issues that have the potential to affect the outcomes of educational research.

Sample Size

Much of educational research is managed on a microcosmic level, within particular schools and regions. Information about viable practices within such settings is not always universally transferable to other groups of learners (Groundwater-Smith, 2004). Groundwater-Smith distinguishes between 'evidence-based practices' and 'evidence-based research' in the following way. Schools and teachers use the former, within their own settings, to pinpoint areas of need and plan future activities. Lawmakers use the latter, from a more global perspective, to direct national and state educational policy (p. 40). It is the efforts of local entities, and not those of large-scale research projects, that lead to adjustments in curriculum, implementation, and interaction between teacher and student (Moore, 2003). One hope is that, in the area of technology in education, the results of large numbers of interrelated studies of similar phenomena will lead to usable information about which programs and teaching strategies lead to optimal results for students (Skinner, 1997).

The Nature of Change within Educational Settings

Another facet of education that complicates the adherence to strict research protocol is the malleable nature of schools and the students within them. Contrary to a general view of education as being a solid, almost immovable entity, changes in the school environment often introduce unexpected elements into a research effort; these new people or modifications to school policies and procedures have the potential to blur the parameters of even the best-controlled studies. In the case of longitudinal studies in educational settings, a major issue is that much can change among participants, goals, etc. (Baker & O'Neil, 1994) before the study is complete. Transferring students, retiring teachers, students that progress beyond the level of learners under study, and changing implementation strategies have the effect of reducing the purity of many studies whose initial goals were to maintain a scientifically sound research environment.

The Duration of Educational Research

Because the educational institution is one in which unexpected changes often occur, it is natural and sometimes necessary to limit the duration of research studies that involve students, teachers, and other uncontrollable events. At the same time, Cuban (1999) cites the short-term nature of educational studies as a fundamental inadequacy that limits their ability to reliably determine the success or failure of an innovation. Immersed in a project for no more than one or two years, support and training for the strategy being tested is removed from teachers and learners before they reach the adoption stage of proficiency with the strategy. For this reason, "it is premature to call the investment in computers in schools a failure because of a lack of evidence for increased productivity and transformed teaching and learning" (p.179).

The Political Nature of Education

Political dynamics can further impact the results of ongoing studies. There can be little argument that education is sometimes the pawn of political adversaries trying to build voter support (Cross, 2004). This situation leads to adjustments in educational policies based on the mood of the nation. Just as funding is provided to support technology in education, money can be rerouted even before the conclusion of the initially promised stream of monies. For example, federal and state grant monies, earmarked for longitudinal studies that span two years or more, can be redirected as a result of changing priorities (Murray, 2004; Murray, 2005). When this happens, the financial support for equipment and professional development diminishes; summary reports, showing results that are less than projected, may reflect a diluted or changed effect of technology on educational outcomes that is more the result of concurrent diluted or changed support than it is the result of a failed implementation plan.

This is not to say that policymakers make decisions capriciously. Rather, they struggle to create rules for various aspects of education that satisfy needs identified by particular groups without raising the ire of other groups. Finding a balance often leads to adjustments to funding and policy, even within the same political tenure of the lawmakers involved in the development of educational policy (Groundwater-Smith, 2004).

The Strength of the Relationship between Previous Research and the Current Study

The review of literature presented herein attempts to encompass studies as similar to the current research as possible. However, such elements as the age groups under study, the circumstances under which technology implementation took place, and the software under examination have the potential to weaken the relationship between studies. Therefore, it is the accumulation of myriad studies and the increasingly convincing evidence that permit conclusions to be drawn between this study of CompassLearning Odyssey and similar—but not identical—studies.

Chapter Summary

The research explored in this chapter points to a variety of elements related to the influence of technology on student achievement. From time spent using computers to teacher attitudes and perceptions, and to the ways in which computers are used, factors outside the domain of specific software intervention programs can affect their ability to improve student achievement.

No different from other educational strategies, the interplay of the software, teacher and student behavior, as well as support and training, have a direct effect on student achievement outcomes with technology. Researchers attempt to include these issues in their work in order to derive meaning from measured changes after an intervention. In addition to the factors named above, educational studies are designed to compare student outcomes by demographic differences among participants: gender, ethnicity, socioeconomic status, identification as learners with special needs, and prior achievement levels are the features of greatest interest to developers of the studies described in this chapter. As evidenced here, the impact of technology on student achievement can vary among members of these demographic groups. Equally important is the observation that specific behaviors and attitudes of teachers, students, and administrators can affect the outcomes of technology-supported instructional interventions.

Having stated the need for research related to the impact of specific computer software programs on student achievement in the first chapter of this document, the second chapter expounded on the path of such research since the birth of CAI. In addition to providing an historical perspective on early efforts at measuring the impact of technology on student achievement, this chapter offers an overview of current research in this area. Because this dissertation focuses on language arts and mathematics achievement, with attention paid to variances based on gender, SES, prior achievement level, and status as learners with special needs, this chapter highlighted research whose foci were of a similar nature.

The next section will discuss the current research project in terms of the student populations under study, the milieu in which the study takes place, and the methods used to gather and analyze data.

CHAPTER III

METHODOLOGY

Research into various studies of educational technology software reveals limited or potentially skewed reports of the efficacy of such material in helping students to perform to higher levels on standardized achievement tests. With accountability and fiscal issues at the core of current educational policies, there exists a need to more accurately evaluate and to report on the impact that specific software tools have on student learning. Having invested millions of dollars in hardware and software, this study will provide data that help school districts and policymakers to direct future expenditures toward those interventions that meet the learning needs of student users.

The objective of this study was to determine whether or not the amount of time students spent using CompassLearning software led to significant differences in student achievement in language arts or mathematics. In addition to general findings between all students, differences in achievement among subgroups of users and nonusers based on demographic differences of gender, SES, prior achievement, and identification as students with special needs were analyzed. After presenting the rationale for using a quantitative research design, this chapter will provide a description of the participants, equipment and materials, and the processes that comprised the study. Included will be a rationale for studying this particular learning software. Based on this methodology, data analysis in Chapter IV will show variations in achievement among all participants as well as among members of the subgroups named above. Included with the description of these elements will be narrative that connects findings to the assumptions and premises that drove the study. The relationship between the outcomes of this study and the results of similar studies discussed in Chapter II will also be highlighted in Chapter IV.

Rationale for the Quantitative Design of this Study

"The quantitative approach is used when one begins with a theory (or hypothesis) and tests for confirmation or disconfirmation of that hypothesis" (Benz, 1998). Such is the case in this study. By exploring the ability of CompassLearning Odyssey language arts and mathematics software to enhance student to perform on standardized achievement tests, within the parameters of quantitative methods, this study will provide replicable and measurable data to support or refute the following hypotheses:

1. There is no significant correlation between level of use of CompassLearning Odyssey language arts software and PSSA reading scores.
2. There is no significant correlation between level of use of CompassLearning Odyssey mathematics software and PSSA mathematics scores.
3. There is no significant gender-based correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
4. There is no significant gender-based correlation between level of use of CompassLearning Odyssey language arts and mathematics software in PSSA achievement scores in mathematics.
5. SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.

6. SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.
7. Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
8. Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.
9. Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
10. Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics based on status as children with or without Individualized Education Plans (IEPs).

CompassLearning Odyssey and student achievement, this study used an *ex post facto design*. Cohen, Manion, and Morrison (2000) describe two types of *ex post facto* research. The first is a design in which differences in essential characteristics or in treatment are imposed on two or more subject groups before the onset of a protocol or process. After the treatment period, the researcher attempts to show a causal relationship between these different characteristics and outcomes. More closely related to the study at hand is the second type of ex facto design: the researcher examines preexisting data among groups that differ in one or more significant ways in order to discern connections between these inherent differences and measured outcomes of one form or another. In the case of this study, the frequency of use of CompassLearning Odyssey had been predetermined by the parameters of the EETT project. The researcher compared achievement levels among these groups in order to learn whether or not the level of immersion with the software was a significant factor in the rate of achievement gain among students. Of course, other variances between students may also influence student achievement over time. For this reason, this study included tests to control for the effect of gender, SES, identification as students with special needs, and prior achievement level. These will be discussed in greater detail later in this chapter.

The Selection of a Specific School District for the Study

While the current dearth of valid research about CompassLearning Odyssey software is sufficient reason to study this product within the context of a dissertation, the fact that Compass software has been widely used across Pennsylvania—despite limited supporting evidence of its ability to enhance achievement on state assessments—adds to the value of a study that occurs within a public school district in Pennsylvania. Krall (S. Krall, personal communication, September 26, 2006) states that the server-based Compass Learning product was in place in 782 Pennsylvania schools; many of these schools continue to use the server-based product. In addition to these, 375 schools in Pennsylvania purchased student licenses for the company's web-based CompassLearning Odyssey product. As mentioned earlier, this indicates that at least 24% of Pennsylvania public schools use some form of CompassLearning software. This study used data from fifth grade students belonging to a school district in a medium sized city in south central Pennsylvania.

Description of the Study Site

At the time of this study, the study site was comprised of one preschool facility, ten elementary schools, two junior high schools, one high school, an alternative high school, and a community education center. Located in central Pennsylvania, the district encompassed 59.6 square miles in Blair County and portions of Logan and Tyrone Townships. During the 2005-06 school year, 8,332 students were enrolled in the district. Data at the end of the 2005-06 school year showed that fifty-two percent of students in the district qualified for free or reduced lunches (Houy, personal communication, February 20, 2007).

Description of Students in the Site's Elementary Schools

While the school district is comprised of ten elementary schools, five were selected for participation in this study. Selection was based on two factors. First, those schools that used CompassOdyssey were selected for participation in the study. Second, one school that used the classic version of Compass Learning software was added to the study as a means of comparing the effect of the two versions on student achievement. In order to ensure that this school (School A) was not demographically different from the four other schools of this study, several tests were conducted. Following the descriptive discussion and representation of findings, Table 1 provides a comparative view of participating and non-participating schools.

Table 1

Comparison of Individual Elementary Schools by Gender, Ethnicity, SES and IEP

	Participating Schools									
	A		B		C		D		E	
	n	%	n	%	n	%	n	%	n	%
Gender										
F	29	39.73	27	57.45	27	46.55	21	44.68	26	47.27
M	44	60.27	20	42.55	31	53.45	26	55.32	29	52.73
Ethnicity										
White	72	98.63	45	97.83	58	100.0	37	78.72	51	92.73
Black	0	0.00	1	2.17	0	0.00	9	19.15	4	7.27
Hispanic	1	1.37	0	0.00	0	0.00	1	2.13	0	0.00
Asian	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Free / Reduced Lunch	32	43.84	27	57.45	22	37.93	39	82.98	41	74.55
IEP	6	8.22	7	14.90	8	8.62	7	14.89	7	12.73

	Non-participating Schools									
	F		G		H		I		J	
Gender	n	%	n	%	n	%	n	%	n	%
F	18	46.15	25	53.19	29	49.15	18	33.96	23	53.49
M	21	53.85	22	46.80	30	50.85	35	66.04	20	46.51

Table 1 (continued)

Ethnicity										
White	33	84.61	46	97.87	57	96.61	50	94.34	40	93.02
Black	6	15.38	0	0.00	2	33.90	3	5.66	6	13.95
Hispanic	0	0.00	0	0.00	0	0.00	0	0.00	1	2.33
Asian	0	0.00	1	2.13	0	0.00	0	0.00	0	0.00
Free / Reduced Lunch	17	43.59	20	42.55	36	61.02	24	40.68	31	72.09
IEP	5	13.16	4	8.51	10	16.95	5	8.47	9	20.93

Table 1 separates individual school data into two categories: schools that participated in the study and schools did not participate in the study. These data show that there is little disparity in characteristics between students in School A and students in the district's other schools. Likewise, as shown in Table 2, the characteristics of students in participating schools are similar to those of students in non-participating schools. However, a multivariate test within the group of participating schools shows (Table 3) that there are significant differences in SES and ethnicity between students in particular schools.

Table 2

Comparison of Demographic Variables by Participation or Non-participation

	Participating Schools A-E		Non-participating schools F-J	
Gender	n	%	n	%
f	130	45.94	113	47.48
m	153	54.06	128	53.78
Ethnicity				
White	266	94.00	226	94.96
Black	14	4.95	17	7.14
Hispanic	2	0.71	1	0.42
Asian	0	0.00	1	0.42
Free/Reduced Lunch	161	56.89	128	53.78
IEP	35	12.37	33	13.87

Table 3

Multivariate Tests(c) of Student Demographics between Schools

Effect	Value	F	Hypothesis df	Error df	P	Partial Eta Squared
Intercept						
Pillai’s Trace	.986	4679.347(a)	4.00	271<.001	<.001	.986
Wilks’ Lambda	.014	4679.357(a)	4<.001	271<.001	<.001	.986
Hotelling's Trace	69.068	4679.357(a)	4<.001	271<.001	<.001	.986
Roy's Largest Root	69.068	4679.357(a)	4<.001	271<.001	<.001	.986
School						
Pillai's Trace	.202	3.644	16<.001	1096<.001	<.001	.051
Wilks' Lambda	.804	3.822	16<.001	828.556	<.001	.053
Hotelling's Trace	.235	3.959	16<.001	1078<.001	<.001	.055
Roy's Largest Root	.196	13.418(b)	4<.001	274<.001	<.001	.164

a Exact statistic
b The statistic is an upper bound on F that yields a lower bound on the significance level.
c Design: Intercept+School

Table 3 shows that there are significant differences with $p < .001$ between students of participating schools. Further analysis by means of a MANOVA test showed that the variables of Free/Reduced Lunch and IEP are significantly different between one or more of schools in the study. Using the Tukey HSD independent t-test, Table 4 shows that School D has a significantly greater number of Black students (the complete Tukey HSD table is contained in Appendix A). Additionally, both School D and School E have significantly more low SES students as evidenced by the variable Free and Reduced Lunch.

Table 4

Tukey HSD Comparison of Student Demographics between Participating Schools

Dependent Variable	(I) School	(J) School	Mean Difference (I-J)	Std. Error	P	95% Confidence Interval	
						Lower Bound	Upper Bound
Ethnicity	D	A	.2066(*)	.04932	<.001	.0712	.3421
		B	.2123(*)	.05470	.001	.0621	.3625
		C	.2340(*)	.05176	<.001	.0919	.3762
		E	.1613(*)	.05239	.019	.0175	.3052
	E	A	.0453	.04709	.872	-.0840	.1746
		B	.0510	.05269	.869	-.0937	.1957
		C	.0727	.04964	.586	-.0636	.2090
		D	-.1613(*)	.05239	.019	-.3052	-.0175
Free/ Reduced Lunch	D	A	-.3914(*)	.08741	<.001	-.6315	-.1514
		B	-.2428	.09694	.092	-.5090	.0234
		C	-.4505(*)	.09173	<.001	-.7024	-.1986
		E	-.0843	.09284	.894	-.3393	.1706

Table 4 (continued)

E	A	-.3071(*)	.08345	-.5363		-.0779
	B	-.1585	.09338	.437	-.4149	.0979
	C	-.3661(*)	.08797	<.001	-.6077	-.1246
	D	.0843	.09284	.894	-.1706	.3393

Based on observed means.
*The mean difference is significant at the .05 level.

The purpose of the above descriptive analysis of student populations within schools was to determine the validity of including School A in the study. While there is no significant difference between School A and the other schools, data show that differences do exist among other schools.

The Need for Quantitative Analysis of the effects of CompassLearning Odyssey

There is little data-driven evidence that shows the efficacy of specific technology software tools in elevating student achievement on standardized tests (Skinner, 1999; What Works Clearinghouse, 2002). Yet, with the help of federal and state funding initiatives, money for technology infrastructure, hardware, and software have poured into public schools since the 1990s (Mendels, 1999). With the current climate of accountability in schools, then, it is valuable for school entities to seek hard data to support their decisions to use or to discontinue use of specific computer-based interventions.

In the case of the software program used in this study, research into the efficacy of CompassLearning Odyssey educational software has led to inconclusive findings about its ability to support student achievement. For this reason, the effect of CompassLearning Odyssey on student achievement has been identified as being “Inconclusive” by the Metiri Group, a firm that reviews studies of technology interventions and provides summary reports about the efficacy of various tools. The categories into which programs might fall include “What Works,” “Promising,” Inconclusive,” and “Can’t Recommend.” By Metiri’s definition, when studies of a technology intervention are inconclusive, “analysis of related research and expert analysis indicates inconsistent and conflicting findings” (C. Lemke, personal communication, November 4, 2006). By examining the effects of CompassLearning Odyssey on student achievement on the PSSA, this research may identify more clearly those aspects of the software that may be effective and those that may be less than effective.

Another impetus to studying CompassLearning Odyssey was the availability of archival data in the selected school district. The school district maintains electronic files that include demographic data, test scores and Compass performance data. All of the data used in this study were derived from this source.

The availability of the school district to the researcher was the final reason for using this particular district for this study. In close physical proximity and with a cooperative administration, it was possible for this researcher to access the data being collected through the EETT project and thereby test hypotheses about the effect of CompassLearning Odyssey mathematics and language arts software on student achievement. Further, the method by which this district (and many others, because such software is costly) added to its infusion of Compass products over the course of several years led to a situation in which students had varying levels of access to the software. This process is described below:

Phase I

After piloting software from Josten's Learning Center and another company, the district found that the Jostens product was a more suitable match in terms of expectations for students and curricular offerings. According to the assistant superintendent, the Jostens software correlated well with the district's curricula (F. Meloy, personal communication, January 17, 2007). In 1996, the school district placed Jostens software in one school at all grade levels. In the years that followed, the district purchased additional licenses for additional schools. (It should be noted that the name "Jostens Learning Center" was changed to "CompassLearning" in 2000.) By 2004, students in all ten elementary schools had access to Compass software in one form or another. At the same time, the software had been upgraded from a program installed on the district's server to an online tool accessible to learners via the World Wide Web. This version of the software was called Compass Learning Odyssey. It is this situation of varying levels of access to the software that led to varying levels of use among students.

Phase II

After teachers, students and families expressed satisfaction with the product, additional monies from grants and internal funding streams provided the same software to additional schools over the course of the next five years. In the meantime, computers and other equipment at the first school were aging; upgrades and replacement hardware added to the district's budget.

Phase III

In 2002, the district purchased licenses for the online CompassLearning Odyssey product (while fully functional, the server-based product was no longer supported by product updates). These were used in Schools B, C, D, and E. School A, because it was slated for infrastructure upgrades at the time of this research project, continued to use the server-based product. Similar to the initial venture, the first experience with CompassLearning Odyssey was at one pilot school.

Cost, training, and physical plant issues make the implementation of technology over time common practices among school districts. It was this situation that facilitated a study of usage level among students. interestingly, this study showed that availability of technology is only one factor that affects usage; in some cases, students will limited availability actually used the software with greater frequency than students with almost unlimited access to technology. These findings will be discussed in Chapter IV. Although the infusion of technology with instruction is impacted by factors that might be explored by qualitative methods (e.g., teacher attitude toward technology, professional development), this study focused only on the relationship between usage and student achievement between various subgroups of students. Having described the research design of the study, the next section will first discuss the EETT grant process that led to the current study. This will be followed by a detailed description of all student participants.

The EETT Grant Process

Hamre & Pianta (2005) identify at-risk students as those with one or a combination of demographic, academic, behavioral, emotional, or social disadvantages. Additional factors that impact school performance are absenteeism and class rank (Alderman, 1999; Dubow & Ippolito, 1994). The EETT grant, as outlined in the school district proposal, focused on two schools in the district whose demographic and academic statistics showed that their students were among those at high risk of failure. The following sections will describe the economic and academic levels of the students at School D and School E as they compare to the district's other elementary schools.

With money provided by allocations from the No Child Left Behind Act of 2002 (Goals 2000: Educate America Act, 1994), PDE awarded EETT funds to qualifying school districts through competitive grants. The economic and academic needs of the schools described in the school district's grant proposal, coupled with the nature of the project described in the EETT grant application to PDE, resulted in a two-year funding stream that provided wireless laptop computers to students in the two schools that were the focus of this study. The school district's proposal targeted students in Grades Three, Four, Five, and Six at Schools D and E. Money gained from this grant was used to provide wireless laptops on carts, projectors, Internet access, and professional development for teachers. The grant also provided money for additional subscription licenses for CompassLearning Odyssey, the standards-based software curriculum used by most of the district's elementary schools, for use by students whose classes were part of the EETT project. This software product will be described later in this chapter.

In addition to requiring districts to follow a specific implementation protocol, the grant stipulated that district personnel must monitor and evaluate the impact of the intervention on identified student outcomes. In the case of this district's EETT project, achievement on the PSSA was the primary measure of the program's effectiveness. The implementation of a technology integration plan that involved experimental and control groups of students made the project appropriate for a quantitative analysis of the program's outcomes.

As described earlier, funding and political issues often alter the direction or the strength of a program. In the case of the district's EETT-supported technology initiative, two significant changes were made after the first year of implementation. First, the dollar amount of the grant was reduced; second, PDE adopted a stance that required more scientifically sound evaluation of the programs underway across the state. While such variations will need to be discussed in Chapter IV, this occurrence actually led to the implementation of an evaluation protocol that supported this quantitative study. To further clarify the project over its duration, the next sections will describe each year of the grant in terms of implementation and monitoring.

Year One

At the start of the grant program, both School D and School E housed either two or three classrooms of students in each grade level. Having determined that Grades Three, Four, Five and Six would use the wireless laptop computers, one classroom at each grade level was identified to participate in the technology integration project during the first year. The choice to participate in either year was not at the discretion of the teachers, but most Year One participants volunteered to take on the responsibility of integrating technology into daily instruction.

The primary goal of the EETT project was for overall scores on the PSSA, in Schools D and E, to show improvement. Reflective of research on the factors that affect achievement, secondary goals were to improve school attendance and to increase parent participation in their children's education. It should be noted that these secondary factors are not part of the research at hand.

To accomplish its objectives, and because it was a PDE requirement, professional development in the integration of technology with curriculum was a primary focus of the grant, with 25% of funds earmarked for teacher training. Training was provided by representatives of the companies that supplied the laptops and the curriculum software. While the EETT project had a multi-dimensional purpose, the focus of this dissertation was limited to the effects of technology integration on student performance on standardized tests. The implementation of the EETT project, as outlined by the grant, provided the necessary materials and an appropriate environment for this study.

Changes in Year Two

Reduced funding in the second year of the project led to the discontinuation of vendor-provided professional development. However, part of the EETT proposal involved the expansion of the initiative to additional classrooms in School D and School E. Teachers who had participated in the program during Year One provided support for new teachers as they integrated technology with daily instruction. In essence, there was little deviation from the original implementation plan. The greater impact was felt in the area of evaluation. The involvement of the Metiri Group, an independent group assigned by PDE to support districts in modifying projects to include more scientific and measurable evaluation procedures, led to the inclusion of students in Schools A, B, and C as control groups for students in Schools D and E. Furthermore, in Year Two, teachers of involved classrooms in all five schools were restricted to using Compass tools for either language arts or mathematics. This process allowed language arts groups to serve as control populations for the mathematics groups and vice versa. The outcome of these comparisons allowed the current research to explore causal relationships between usage and achievement. The separation between language arts and mathematics usage made it possible to note whether or not one part of the software (language arts or mathematics) had a different effect on student achievement than had the other.

The following description of student participants accounts for groups of children in the five elementary schools identified to participate in this study.

Participating Schools

As described above, two schools were part of the original EETT project. However, as a result of the district's collaboration with the Metiri Group, two schools were added to the study. The schools and students that participated in this study had pre-selected by the Metiri Group based on their access to the online CompassLearning Odyssey software.

Data from a fifth school were collected by the researcher in order to provide a comparison in usage between the server-based and the online versions of CompassLearning software. Because it was undergoing renovation this school, named School A, was the district's only school that had not yet moved to the online CompassLearning Odyssey software. Teachers and students in School A were allowed to use the programs with no manipulation from administrators or Metiri personnel; they were not required to use only the mathematics or the language arts software. In order to ensure that that these factors did not influence the outcomes of the study, preliminary descriptive analyses were conducted. Results showed that the students of School A were similar to students in Schools B, C, D and E in terms of demographics and the range in usage levels of the educational software available to them (Table I).

Schools identified for participation were selected because they represented three levels of access to the CompassLearning Odyssey software: the terms “no access,” “weekly access,” and “daily access” describe the range of access to Compass learning software that will be discussed in the next sections of this chapter. Schools also represented a reasonable representation of the district’s total student population in terms of SES and prior achievement levels.

Schools with No Access to CompassLearning Odyssey

Because it was in the process of being renovated, the Compass tools in School A had not yet been upgraded to the web-based CompassLearning Odyssey version of the learning software. The school’s infrastructure did not lend itself to the upgrade until a building renovation project had been completed. For this reason, students and teachers in School A used the Compass Classic version of the company’s software. A standalone product, Compass Classic provided lessons, feedback, and report capabilities similar to those available with the web-based product. However, regular upgrades had been discontinued prior to the start of the 2004-05 school year. Students accessed Compass only during their assigned time in the computer lab.

Schools with Weekly Access to CompassLearning Odyssey

While School B and School C were outfitted with CompassLearning Odyssey, access by students was restricted to weekly assigned time in the computer labs. Because the web-based software was upgradeable via regular enhancements by the company, students were exposed to lessons they hadn’t seen before and programs had a more modern appearance. The content of the Odyssey software was comparable to that of the Classic software.

Schools with Daily Access to CompassLearning Odyssey

Unlike the first three schools, Schools D and E were fully supported as they used CompassLearning Odyssey. As stated earlier, this infusion was the result of a state-funded technology integration initiative. In addition to the option of accessing CompassLearning Odyssey during assigned time in the computer lab, teachers could assign modules to students to complete on the wireless laptop computers, either in the classroom or at home. Yet, while opportunity to use CompassLearning Odyssey was more plentiful, the introduction of laptops to the classrooms also led to exploration into alternate ways to infuse technology into daily activities. The following section will detail the project as it was planned and implemented in Schools D and E.

Advantages and Disadvantages of Classic versus Odyssey versions of the Software

While School A lacked the upgrades to the CompassLearning software available to the other schools, there were some advantages to the older software version for teachers as they developed lessons and assessments. Most important, they were familiar with the programs. Assigning tasks that matched classroom curricula was easier for these teachers than it was for teachers learning the particulars of the online version. The lessons had also been aligned to the district's curriculum; while both versions were aligned to state standards, alignment of CompassLearning Odyssey to the district's curricula had not been completed at the time of this study. At the same time that students were using new materials, teachers bore the burden of learning new methods of assigning lessons and manipulating the changes inherent in the CompassLearning Odyssey version of the instructional tool they were expected to use. On a positive note, the infusion of

CompassLearning Odyssey was supported by in-house intervention from a Compass-trained district employee.

Table 5 describes each school in terms of access and use of CompassLearning software.

Table 5

Comparison of Access to CompassLearning Software by School

	School				
	A	B	C	D	E
CompassLearning Classic	YES				
CompassLearning Odyssey		YES	YES	YES	YES
Access in computer lab only	YES	YES	YES		
Access in computer lab and via laptops			YES	YES	YES
Home access to CompassLearning Odyssey		YES	YES	YES	YES
Professional Development support		YES	YES	YES	YES
Curriculum aligned to state standards	YES	YES	YES	YES	YES
Curriculum aligned to district curricula	YES				
Prior experience with the software	YES			YES	YES

Having described the students in each school and the circumstances under which groups of students used CompassLearning Odyssey software, the next section will describe the software intervention used in the study. This will be followed by a description of the academic and economic levels of the families whose children attend the schools.

Description of CompassLearning Odyssey Software

Since 1988, the school district has maintained a relationship with Compass, an educational software development company that provides standards-based learning, assessment, and reporting tools. The software has evolved from programs installed directly onto district servers to a web-based tool that can be accessed from any location. For the purposes of this study, the version used by students in School A will be called server-based or Classic software; the Software used by the remaining schools will be called online or web-based software.

The primary differences between the two versions of software are their accessibility and the ease with which they can be upgraded. Both versions allow teachers to create assignments, individualized “learning paths” based on student performance on specific skills, and assessments that report student outcomes on assigned tasks. The Server-based software was aligned directly with the district’s elementary curriculum; at the time of this study, the newer web-based software had not been aligned to the district’s curriculum.

The tasks described above are part of the curriculum for elementary students across the district. While students in School A accessed server-based software assignments during assigned computer lab times only, members of Schools B, C, D and E were able to complete these tasks from either the computer lab or their classroom. Access to wireless laptops was limited at Schools B and C; one cart of laptops was available for teachers to sign out and use. Being shared among all grade levels, access to the wireless laptops was limited. In Schools D and E, because wireless laptops with Internet connectivity had been provided to particular teachers and students, users had opportunity to access CompassLearning Odyssey software from any location within and outside the school setting. Students were able to access and complete online tasks at any time of day, and could spend more than one half-hour per day using the web-based software and the Internet. Other technology-based activities (word processing, research, etc.) also occurred regularly.

The server-based software used by teachers and students in School A was an older version of the same software used by the other schools. Similar to students in Schools B and C, this product was accessed according to the mandates of the district's elementary technology curriculum: one half hour daily during the students' assigned time in the computer lab. Lab time was also the only access afforded to students in Schools A, B, and C for any other technology applications such as research via the Internet and preparation of assignments with word processing tools. For this reason, it was possible for students in the first three schools to participate in no Server-based software activities for weeks at a time.

As with many computer-based educational software systems, CompassLearning Odyssey consists of instructional materials that are aligned to the educational standards set by individual states. Included in the package is a pre- and post-test component that covers standards-based objectives by grade level. Within each series of lessons are learning objectives, instructional modules, and related assessments. After students complete an assessment, teachers have the option to assign them to the individualized "learning path" that was created based on the items students did not successfully complete.

The availability of the Internet has changed the delivery mode of most educational software. Earlier versions relied on districts' internal servers to load and store programs and student data. In this school district, computer labs were the usual location in which students accessed curriculum software. In the new web-based scenario, instructional tools and data can be accessed from outside the school district's server domain. Renamed CompassLearning Odyssey, Compass programs are now web-based and accessed via the Internet. When students have easy access to technology from within their classrooms, it is more feasible for teachers to integrate software-based instruction into daily curriculum.

The above overview of CompassLearning Odyssey, as it is used by students in the district, leads to the following description of the student users themselves. After discussing participants in general terms, the characteristics of students in terms of the variables under examination will be explored.

Participating Students

The EETT-funded project described above was particularly suited for a study using independent t-test analyses available through SPSS. Both School D and School E had at least two classes in each of the grade levels under study. In Year One of the grant process, one class in each grade level was targeted for the technology intervention. This allowed for the formation of control and experimental groups as described earlier (half of the group was restricted to using CompassLearning Odyssey's language arts software while the other half used only the mathematics software of CompassLearning Odyssey). The purpose of the grant's designers was to measure the overall impact of technology integration on student achievement on the PSSA. In order to further explore whether or not technology had varying effect on achievement for children based on demographic or achievement issues, achievement gains of participating students were compared on the basis of gender, prior achievement level as shown by Grade Three scores before participation in the technology intervention, poverty level as measured by free/reduced lunch records, and pre- and post-test scores on CompassLearning Odyssey's standards-based assessment.

The number of involved classes over the two-year time period was 14. Four of the classes were assigned to use CompassLearning Odyssey only for language arts while seven classes used it only for mathematics. 280 students participated in the study. Of these, 130 students were female and 150 were male.

Because there is interest in learning whether or not technology has a different impact on boys than on girls, an effort was made to measure gender differences in the effect of technology on scores on standardized tests. Similarly, further analyses involved examining results between students of varying SES or ability levels. These areas are further described in the next paragraphs.

Levels of Economic and Academic Need of Participating Students

With the exception of students whose parents write boundary letters requesting that their children attend a different school (these parents must provide transportation to and from the alternate school and get permission, from the principal of the receiving school, for their child to attend a school other than the one closest to their home), each of the district's ten elementary schools is attended primarily by the children of families that live within proximity of that school. Since there are pockets of affluence and poverty within the various neighborhoods that comprise the school district, this has led to a situation in which some schools have disproportionately high numbers of students at risk of school failure.

Economic Levels of Participating Schools

The poverty level within a school is determined by the percentage of students eligible for free or reduced lunch. As described earlier, significantly more students in Schools D and E are of low SES than those of other schools in the district; this was part of the reason for targeting Schools D and E for the EETT grant. Table 6 shows the proportion of students in each participating school that receives free or reduced lunch.

Table 6

Comparison of Schools by the Variable Free or Reduced Lunch

	Free or Reduced Lunch				
	Yes	Percent	No	Percent	Total
School A	32	43.84	41	56.16	73
School B	27	55.56	20	42.55	47
School C	22	37.93	36	62.07	58
School D	39	82.98	8	17.02	47
School E	41	74.55	14	25.45	55
Total	161		129	100.00	280

Academic Levels of Participating Schools

The study included 303 fifth grade children. Because personal identifiers were removed from archived data, the researcher had no knowledge of the specific children involved. The researcher accessed student data through a representative of the district's technology department who assigned random alphanumeric labels to data.

As part of an overall data collection process, the PSSA scores of students in the district's elementary schools are tracked from year to year. Scores from participating students' Grade Three PSSA were used as the baseline for this study. The rate of change between Grade Three and Grade Five PSSA scores were the determinant of the impact that CompassLearning Odyssey had on student achievement in language arts and mathematics.

Learners with Special Needs

Forty students with learning disabilities were part of this study. As a matter of sheer coincidence, each of the five schools under study reported having eight fifth graders with IEPs. While additional students had speech, hearing, or vision impairments, only students with identified specific learning or emotional impairments were included in the category of learners with special needs. The reason that students with emotional issues were included is that the two students in this category had been identified as having both specific learning and emotional disabilities. Table 7 shows the percentage of students at each building who had IEPs.

Table 7

Comparison of Schools by the Variable IEP

	IEP				
	Yes	Percent	No	Percent	Total
School A	6	8.22	67	91.78	73
School B	7	14.89	40	85.11	47
School C	8	13.79	50	86.21	58
School D	7	14.89	40	85.11	47
School E	7	12.73	48	87.27	55
Total	35	100.00	245	100.00	280

Having provided a rationale for the design of this study, this section described the students involved in the study on the basis of the factors being studied. The next section will provide insight into the specific tests used to analyze data about the effect of CompassLearning Odyssey on student achievement.

Procedures of the Study

The procedures of this study are best presented by an initial description of the process of descriptive analysis used in defining the characteristics of participating groups. This information will be followed by a discussion of the procedures used in answering the research questions of the study.

Description of Group Characteristics

The fifth grade students involved in this study comprised about half of the district's total grade five population. Students in fifth grade classrooms of participating schools, as part of the EETT initiative, had been assigned to either the language arts or to the mathematics component of CompassLearning Odyssey. Since students had been assigned to classes before the start of the study, the selection of students was the result of randomized clustering. Coming from five different elementary schools, descriptive analyses were conducted in order to define the characteristics of the groups. These analyses revealed the existence of any significant differences between language arts and mathematics groups in the areas of gender, SES and identification as students with special needs.

Following descriptive analyses, independent t-tests were conducted to measure the correlation between the dependent and independent variables. In isolation, though, independent t-tests are an insufficient determinant of a valid relationship. It is necessary to consider the impact of other variables as influencers of this relationship. For this reason, multiple regression analyses were conducted. The next sections will discuss the use of both of these tests in this research.

Answers to the Research Questions

As students had been assigned to particular teachers' classrooms before the EETT project had received approval or funding, their participation in the project was predetermined by their assignment to a particular classroom. A clustered sampling method had been used to determine the role of student participants; classrooms of students had been assigned to either the language arts or to the mathematics group as the district developed its EETT project in Year Two.

Because this study was quantitative in nature, SPSS was used to analyze data. This software system is appropriate for making univariate and multivariate statistical analyses. The focus on two factors (language arts and mathematics software) would have allowed for the use of independent t-tests to determine causality between variables. In this case, the dependent variable was PSSA scores. The amount of time students spent using either the language arts or the mathematics portion of CompassLearning Odyssey was the independent variable. The independent t-test showed the degree to which the variance in PSSA scores might have been attributable to the amount of time spent with the software.

The rationale for including ANCOVA was the fact that differences among students can play a significant role in the causal relationship shown by such a test. According to Cohen, Manion, and Morrison (2000), multiple regression analyses nullify the effects of those variables that, while they are not part of the study, may have direct bearing on outcomes. Controlling for the effect of such "nuisance variables" (Dugard & Todman, 2001, p. 13) strengthens the internal validity of the study and supports any assumptions made about the causal relationship between the dependent and independent variables (Dugard & Todman, 2001). For this reason, ANCOVA was used to analyze data. ANCOVA is a form of multiple regression analysis and, as stated by Cohen, Manion, and Morrison (2000), "multiple correlation measures indicate the degree of association between three or more variables simultaneously.... Multiple correlation, or 'regression' as it is sometimes called, indicates the degree of association between *n* variables" (p. 198). The covariates controlled by ANCOVA were gender, SES, identification as students with special needs, and prior achievement levels. By controlling the effect of these demographic variables, ANCOVA allowed for the assumption that there was relative homogeneity among groups.

Another reason for using ANCOVA as an analysis tool was that, since participating students' third grade PSSA scores had been used as the baseline against which progress would be measured, these scores could be seen as the PSSA pre-test. Students' fifth grade PSSA performance could then be viewed as post-test scores. ANCOVA tests are suited to the analysis of pre-post data (Dugard & Todman, 2001).

Both 4Sight and CompassLearning Odyssey pre- and post-tests were designed to correlate directly to the PSSA. In the interest of establishing confidence that a correlation does exist between PSSA pre- and post-test scores and 4Sight pre- and post-test scores, ANCOVA tests were conducted with the data (PSSA and 4Sight). Since the district used the 4Sight batteries in its work with students during the time of the study, it was helpful to determine the existence of a relationship between the tests. Additionally, identifying a relationship between PSSA and the 4Sight assessment tools may serve to strengthen the confidence with which schools use such tools in their support of student learning.

Chapter Summary

The EETT grant included a variety of elements that fostered systemic change in attitude toward, and integration of, technology with daily curriculum. The inclusion of strategies for enhancing the effective use of technology, teacher attitudes, and parent participation must be recognized as part of the reason that technology shows effectiveness in raising student achievement on standardized tests. While such issues as teacher attitudes toward technology as an instructional tool, parent attitudes toward their children's school experiences, and student attitudes toward learning are evidenced here as fodder for further study, they are not part of the current exploration. This study has examined the outcome of student performance on the PSSA as the study's dependent variable. The independent variable of time with the software intervention was tested while calculating for such demographic factors as gender, SES, status as students with special needs, and prior achievement level.

Teachers and students were randomly selected and assigned to groups. This fact has helped to increase the probability that the study can be replicated among similar groups of teachers and learners. The inclusion of descriptive statistical analysis will help other researchers determine whether or not their target population matches that used in this study.

The primary test for this research was ANCOVA, a form of multiple regression analysis that is appropriate for measuring outcomes of pre-post tests. The use of ANCOVA allowed for the reasonable assumption that variances in PSSA scores (the dependent variable) were the result of time spent on CompassLearning Odyssey software (the independent variable).

Having outlined the methodology of this study, the next chapter will discuss the results of the analyses. Included will be summaries of overall student outcomes, a synopsis of the influence of demographic factors on PSSA achievement, and exploration of the correlational differences between CompassLearning Odyssey use and achievement scores between language arts and mathematics groups. Discussion will also cover the relationship between the three assessments used by the district: PSSA, 4Sight, and CompassLearning Odyssey.

CHAPTER IV

RESULTS

The purpose of this quantitative study was to determine the extent to which CompassLearning Odyssey software affected student achievement as measured by the PSSA. Specifically, interest was in the correlation between usage levels and achievement. This chapter will discuss findings related to each of the following hypotheses:

1. There is no significant correlation between level of use of CompassLearning Odyssey language arts software and PSSA reading scores.
2. There is no significant correlation between level of use of CompassLearning Odyssey mathematics software and PSSA mathematics scores.
3. Gender has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
4. Gender has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software in PSSA achievement scores in mathematics.
5. SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
6. SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.

7. Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
8. Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.
9. Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
10. Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.

Organization of the Presentation of Results

After first providing descriptive analyses of participants as described in Chapter III, both independent t-tests and ANCOVA analyses were conducted in order to account for the effect of such variables as gender, SES, identification as students with special needs, and prior achievement level. This process nullified the effect of such variables as influencers on the impact of CompassLearning software on student achievement. Further analyses were conducted in order to determine the significance of relationships between level of use of CompassLearning software and student achievement. Specifically, multivariate tests(b), multivariate tests(c), tests of between-subjects effects, and tests of within-subjects effects were the primary tools for analyzing data for this study.

In order to provide results of the tests in a digestible format, discussion will focus first on the effect of CompassLearning on language arts achievement (Hypothesis 1). This will include a comparison of students based on gender, SES, prior achievement level, and identification as students with special needs (Hypotheses 3, 5, 7 and 9 respectively). The second section will focus on the effect of CompassLearning on mathematics achievement (Hypothesis 2). This will include a comparison of students based on gender, SES, prior achievement level, and identification as students with special needs (Hypotheses 4, 6, 8 and 10 respectively).

For the purpose of simplifying the discussion of findings, several questions related to the hypotheses for both language arts and mathematics will form the basis for dialogue:

1. Is there a significant difference in the change among users of mathematics versus users of language arts versus users of CompassLearning's server-based product?
2. Based on level of use, is there a significant change from pretest to posttest? Is the change based on Minutes per Month similar to or different from the change based on Minutes per Activity?
3. Is the change from pretest to posttest impacted by gender, SES, prior achievement level, or identification as students with special needs?

A final section of this chapter will report on the strength of the correlation between 4Sight predictive scores and scores on the PSSA in both reading and mathematics.

The Effect of CompassLearning Odyssey on Reading Achievement

Odd-numbered hypotheses (1, 3, 5, 7, and 9) relate to language arts. The first states that “there is no significant correlation between level of use of CompassLearning Odyssey language arts software and PSSA reading scores." Hypotheses Numbers 3, 5, 7 and 9 relate to the variables of gender, socioeconomic status, prior achievement and identification as students with special needs. This discussion will first focus on the first hypothesis; the four ancillary hypotheses will then be discussed collectively.

The first null hypothesis stated that “there is no significant correlation between level of use of CompassLearning Odyssey language arts software and PSSA reading scores.” To determine the validity of this statement, Multivariate Tests(c) were conducted. The Wilks’ Lambda significance in Table 8 shows that the interaction between Reading and CL subject is significant at $p<.001$. This means that there is a relationship between usage of CompassLearning language arts software and reading performance on the PSSA. Specifically, students who used the language arts software showed a significant decline in performance on the reading posttest. This indicates a strong negative correlation between usage of the software and performance on the PSSA reading test. The full Multivariate Tests(c) table can be found in Appendix B, and corresponding F tests for the multivariate tests appear in Appendix C.

This unexpected outcome could stem from a variety of factors ranging from teacher attitude toward CompassLearning Odyssey language arts software to students’ ability to use the software independently. Further research would be needed in order to pinpoint the cause of a negative correlation between language arts software use and reading achievement scores.

Table 8

Wilks' Lambda: Correlation between Use of CompassLearning Software and Reading Achievement

Effect	Value	F	Hypothesis df	Error df	p
Reading	.995	1.294(b)	1<.001	277<.001	.256
Reading * CL Subject	.914	13.014(b)	2<.001	277<.001	<.001

a Computed using alpha = .05
b Exact statistic
c Design: Intercept+CLsubject
Within Subjects Design: Reading

Question One

Is there a significant difference in the change in reading achievement among users of mathematics versus users of language arts versus users of CompassLearning's server-based product? Because students accessed different components of CompassLearning Odyssey, and members of School A accessed only the Classic version of the software, there is interest in knowing whether or not there was a significant difference in reading achievement outcomes between groups of users. A test of between-subjects effects (Appendix D) shows that there is no significant difference among students who used CLO language arts or mathematics, or CompassLearning's server-based software. However, findings point to the fact that users of mathematics software experienced the only gains on the reading posttest. Figure 1 shows that users of mathematics software showed gains on the reading subtest of the PSSA; conversely, users of language arts software, as well as users of the Classic version of software, showed declining scores from pretest to posttest.

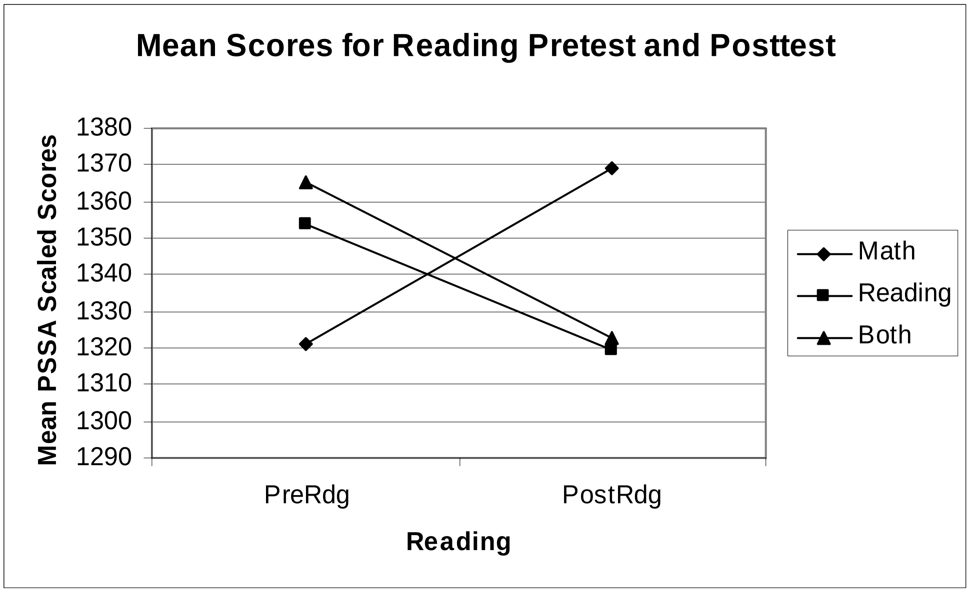

Figure 1. Mean scores for reading pretest and posttest by CompassLearning subject. Reading posttest scores improved for users of CLO mathematics software. Among users of CLO language arts software and users of Classic CompassLearning software, pre-posttest scores declined.

Question Two

Based on level of use, is there a significant change from pretest to posttest? Is the change noted in Minutes per Month similar to or different from the change based on Minutes per Activity? Figure 2 indicates that there is a direct positive relationship between the amount of time students spent using CompassLearning Odyssey language arts software each month and PSSA achievement. Students who used the software fewer than 100 minutes per month experienced declines from pretest to posttest. All students who used the software for 100 minutes or more experienced a gain of approximately ten points from pre- to posttest. Interestingly, no student registered monthly usage in the ranges of 200-299 or 300-399 minutes. While there is no reason for this occurrence based on the usage protocol for the study, it is possible that usage followed an "all or nothing" pattern: Some teachers may have made CLO the primary focus of student computer time while others may have developed other online assignments or allowed students leeway in the work they did while using computers. If the latter is true, an area of interest to future researchers might be a comparison of student interest in CompassLearning Odyssey software with their interest in other similar tools. It is possible that familiarity with any program leads to diminished interest and a subsequent diminished positive effect on achievement.

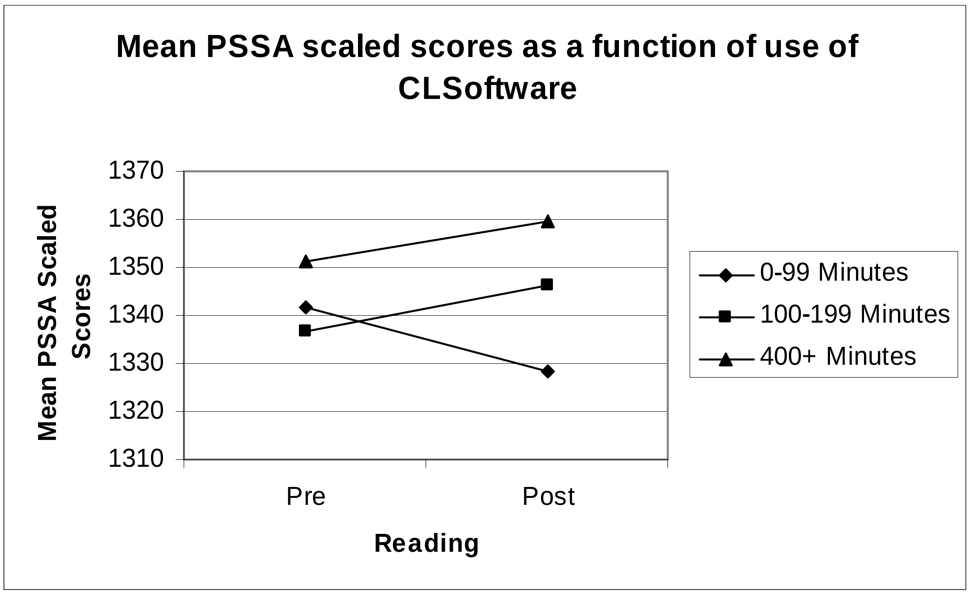

Figure 2. Reading posttest gains as related to monthly usage of CompassLearning software. An increase in the amount of time spent each month seems to positively affect language arts achievement outcomes on the PSSA.

The second part of Question Two relates to whether or not the number of minutes per session affects changes in achievement from pretest to posttest. Interest in this aspect of usage rests in the fact that students, while spending the same amount of time with the software, varied greatly in the amount of time they spent on individual activities within the software. Contrary to the expectation that meaningful learning might occur when students spend significant amounts of time working with individual activities, Figure 3 shows that posttest scores declined as students spent more minutes on individual activities. Students who spent fewer than ten minutes on specific activities showed the only, albeit modest, gains on the PSSA posttest. It can be conjectured that students lose focus when working within isolated activities for extended periods of time. Future study might more closely examine the relationship between time per activity and effective technology-based learning.

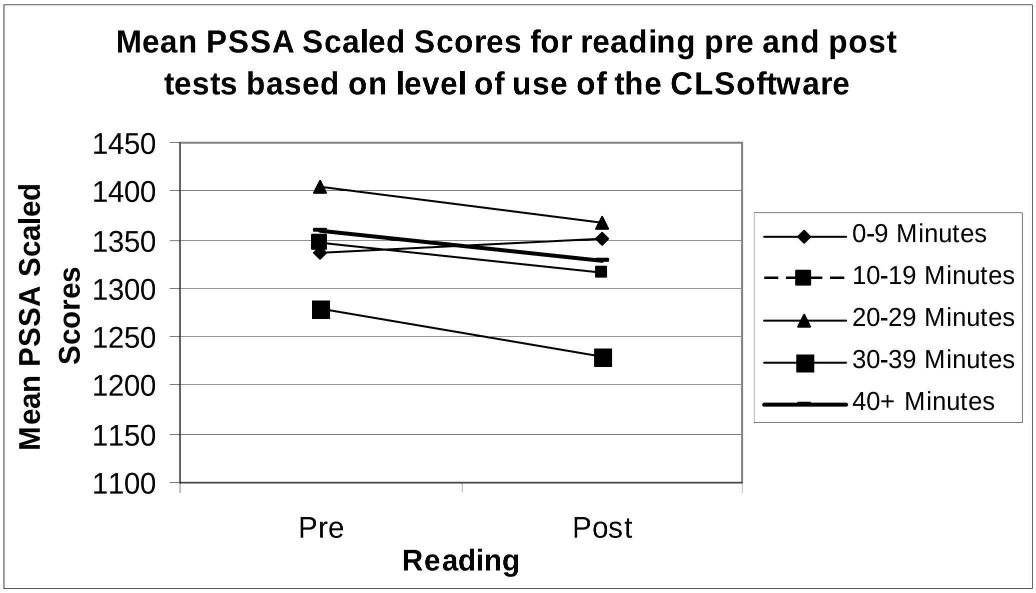

Figure 3. Reading posttest gains as related to per-activity usage of CompassLearning software. An increase in the amount of time spent on individual activities seems to negatively affect language arts achievement outcomes on the PSSA.

Regarding the significance of the relationship between usage and achievement, a Multivariate Test(c) was conducted. Based on Wilks' Lambda, there is a significant difference in student performance on the pretest and posttest of this study. Table 9 shows that the significance rests between reading achievement and Minutes per Activity. It can be inferred that, while more time with technology per month did lead to higher posttest scores, the differences were not at a level of significance. The complete table can be seen in Appendix E; Appendix F shows the corresponding F tests for the multivariate tests.

Table 9

Wilks' Lambda: Correlation between Minutes per Activity with CompassLearning Software and Reading Achievement

	Value	F	Hypothesis df	Error df	p
Reading	.983	4.652(b)	1<.001	267<.001	.032
Reading * CL Min/Month	.993	.965(b)	2<.001	267<.001	.382
Reading * CL Min/Activity	.955	3.135(b)	4<.001	267<.001	.015
Reading * CL Min/Month * CL Min/Activity	.970	1.388(b)	6<.001	267<.001	.219

a Computed using alpha = .05
b Exact statistic
c Design: Intercept+CL Min/Month+CL Min/Activity+CL Min/Month * CL Min/Activity
Within Subjects Design: Reading

When examining the relationship between variables, a Test of Between-Subject Effects showed that there were no significant differences between groups based on use of CLO language arts, mathematics, or server-based software. Table 10 shows that there is no interaction between the variables of Minutes per Month and Minutes per Activity. This indicates that group differences are not the reason for any significance or lack of significance in results related to time on task. In other words, using one form of CompassLearning software over another did not affect achievement outcomes.

Table 10

Correlation between Usage Groups, Time on Task in Reading, and Achievement

Source	SS	df	MS	F	p
CLMin per Month	154232.601	2	77116.300	1.514	.222
CL Min/Activity	223573.780	4	55893.445	1.097	.358
CLMin perMonth* CL Min/Activity	324012.258	6	54002.043	1.060	.387

a Computed using alpha = .05

Question Three

Is the change from pretest to posttest impacted by gender, SES, prior achievement level, or identification as students with special needs? Unlike many of the studies discussed in Chapter II, this study did not reveal a correlation between socioeconomic status and reading achievement based on the use of technology. Similar to other studies, no correlation was found to exist between gender and achievement based on technology use. However, a strong correlation (p<.001) was shown to exist between prior achievement and use of technology. While a similar correlation exists between identification as students with special needs, the sample size was small (η^2=.038); therefore, while such a relationship is to be expected, results might be viewed with caution. Table 11 shows the relationship between gender, SES, prior achievement, IEP and achievement. The complete table appears in Appendix G.

In summary, gender and SES had no effect on reading outcomes for this study, though it does seem that prior achievement levels (pretest) are significantly correlated to posttest gains. This may suggest that children progress at a rate that is difficult to change; higher-performing third graders from 2004 will have progressed at a faster rate than lower-performing third graders and will therefore show greater gains on a 2006 posttest. Finally, as may be expected, being identified as students with special needs appears to be significantly correlated to achievement gains.

Table 11

Comparison of Gender, SES, Prior Achievement, IEP, and Reading Achievement

Source	SS	df	MS	F	p
Corrected Model	923377.005(b)	8	115422.126	6.166	<.001
Intercept	575203.822	1	575203.822	30.729	<.001
Gr3RdgScaled	613265.079	1	613265.079	32.763	<.001
Gender	13399.297	1	13399.297	.716	.398
SES	48786.905	1	48786.905	2.606	.108
IEP	201719.858	1	201719.858	10.777	.001
Gender * SES	6066.678	1	6066.678	.324	.570
Gender * IEP	17091.530	1	17091.530	.913	.340
SES * IEP	42394.021	1	42394.021	2.265	.134
Gender * SES * IEP	4315.924	1	4315.924	.231	.631
Error	5072696.420	271	18718.437		
Total	5996075<.001	280			
Corrected Total	5996073.425	279			

a Computed using alpha = .05
b R Squared = .154 (Adjusted R Squared = .129)

The finding that SES did not have a significant effect on achievement among users of language arts software is inconsistent with current research that finds a relationship between poverty and achievement. It is possible that this outcome results from the fact that there was a negative correlation between use of CLO language arts software and achievement. It might that, in a study of language arts software that showed a positive correlation to achievement, a significant variance in gains might have been seen between groups of children based on SES.

Summary of Findings Related to Reading

Based on the information in this section, the first null hypothesis is rejected. There is significant negative correlation between levels of use of CompassLearning Odyssey language arts software and student reading achievement. In addition, a positive relationship exists between minutes per month and student achievement. Conversely, a negative relationship exists between minutes per activity and student achievement.

Based on the above discussion, Hypothesis Number 3, "Gender has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading," is not rejected. This study found no correlation between gender and achievement gains in reading. Similarly, Hypothesis Number 5, "SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading," is not rejected. In this study, no significant relationship was found between pretest and posttest scores based on socioeconomic status.

Hypothesis Number 7, "Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading," is rejected. In this study, the significance levels for prior achievement were at or below the .001 threshold, suggesting that students maintain specific learning curves over the course of time.

Hypothesis Number 9, "Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading," is rejected. Although the significance levels for IEP are the same as for Prior Achievement, the small sample size dilutes the conviction with which this statement can be made. Yet, given the fact that members of this group had been identified with specific learning disabilities, it can nevertheless be expected that the correlation is a natural occurrence and will be found to exist in similar studies.

The Effect of CompassLearning Odyssey on Mathematics Achievement

Even-numbered hypotheses (2, 4, 6, 8, and 10) relate to mathematics. The first states, "There is no significant correlation between level of use of CompassLearning Odyssey mathematics software and PSSA mathematics scores." Hypotheses Numbers 4, 6, 8 and 10 relate to the variables of gender, socioeconomic status, prior achievement and identification as students with special needs respectively. This discussion will first focus on Hypothesis Number Two; the four ancillary hypotheses will then be discussed collectively.

To determine the validity of the first hypothesis related to mathematics, Multivariate Tests(c) were conducted. The Wilks' Lambda significance in Table 12 shows that the interaction between Mathematics and CL Subject is significant at $p<.05$. This indicates that there is a relationship between usage of CompassLearning software and mathematics performance on the PSSA. The complete multivariate tests related to this table can be found in Appendix H.

Table 12

Wilks' Lambda: Correlation between Use of CompassLearning Software and Mathematics Achievement

	Value	F	Hypothesis df	Error df	p
Mathematics	.972	7.654(b)	1<.001	267<.001	.006
Mathematics * CL Min/Month	.993	.914(b)	2<.001	267<.001	.402
Mathematics * CL Min/Activity	.944	3.960(b)	4<.001	267<.001	.004
Mathematics * CL Min/Month * CL Min/Activity	.989	.503(b)	6<.001	267<.001	.806

a Computed using alpha = .05
b Exact statistic
c Design: Intercept+CL Min/Month+CL Min/Activity+CL Min/Month * CL Min/Activity
Within Subjects Design: Mathematics

Question One

Is there a significant difference in the change in mathematics achievement among users of mathematics versus users of language arts versus users of CompassLearning Odyssey's server-based software? Because students accessed different components of CompassLearning Odyssey, and members of School A used only the Classic server-based version of the software, there is interest in knowing whether or not there was a significant difference in mathematics achievement outcomes between groups of users. As discussed above, Tests of Between-Subjects Effects showed that members of each user group (CLO language arts, CLO mathematics, and CompassLearning's server-based software) are not significantly different from each other. For this reason it can be accepted that differences in achievement gains are the result of variations in technology usage.

Figure 4 shows that, while all groups showed gains on the mathematics posttest, the group that used CLO mathematics software showed the greatest gains. Recalling information about gains in reading achievement, it is noteworthy that students in the CLO mathematics group made greater gains in the both reading and mathematics posttests.

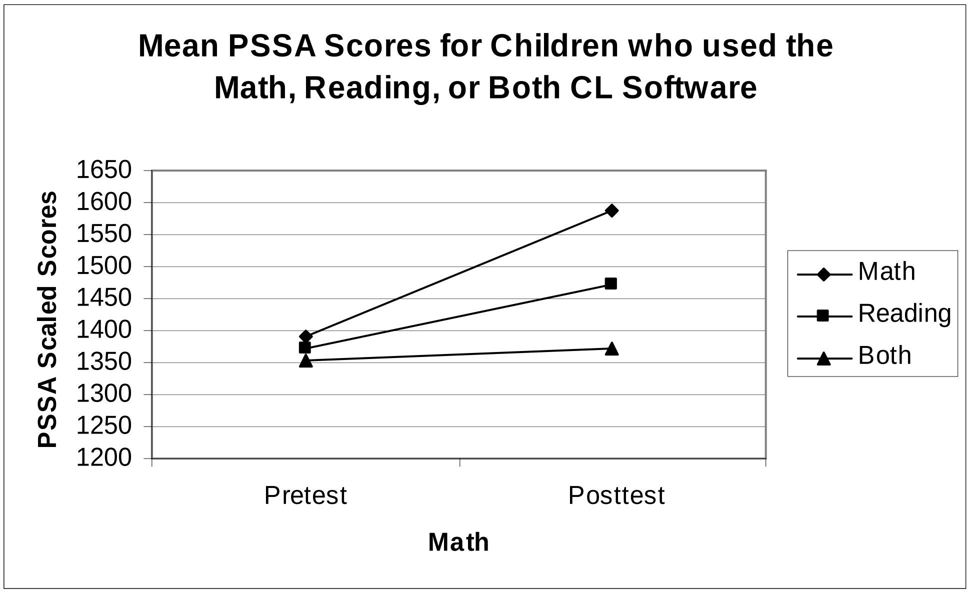

Figure 4. Mean scores of participating students by use of CLO mathematics, language arts or CompassLearning's server-based software. While all groups showed gains, the most significant growth is seen among children who used CLO mathematics software.

To determine the significance of the gains shown in Figure 4, Multivariate Tests(c) were conducted. Looking at Wilks' Lambda, there is a significance at the $p<.01$ level for students who used CLO mathematics software. Table 12 shows that, while all showed gains, students who used the mathematics software experienced greater achievement gains than students who used either CLO language arts software or CompassLearning's server-based software. The full table appears in Appendix H.

Question Two

Based on level of use, is there a significant change from pretest to posttest? Is the change shown in Minutes per Month similar to or different from the change based on Minutes per Activity? A Test of Between-Subjects Effects (Table 13) shows that there is indeed a significant main effect at the p<.05 level for Minutes per Month. A similar effect at the p<.05 level is evident for Minutes per Activity. The full table can be found in Appendix I. Interestingly, while the greatest gains in achievement were among students who used mathematics software for long periods of time over the course of a month, the greatest gains in terms of minutes per activity were seen among children who attended to single activities for short periods of time. This finding warrants further investigation in order to determine the relationship between software use and achievement gains.

Table 13

Comparison of Mathematics Achievement by Minutes per Month and Minutes per Activity

Source	Type III Sum of Squares	df	Mean Square	F	p
Intercept	175143155.026	1	175143155.026	2772.801	<.001
CL Min/Month	421165.623	2	210582.812	3.334	.037
CL Min/Activity	622327.698	4	155581.924	2.463	.046
CL Min/Month * CL Min/Activity	192779.724	6	32129.954	.509	.802
Error	16864974.239	267	63164.698		

a Computed using alpha = .05

As shown in Figure 5, it appears that the monthly amount of time spent using CompassLearning Odyssey mathematics software has a positive effect on student achievement.

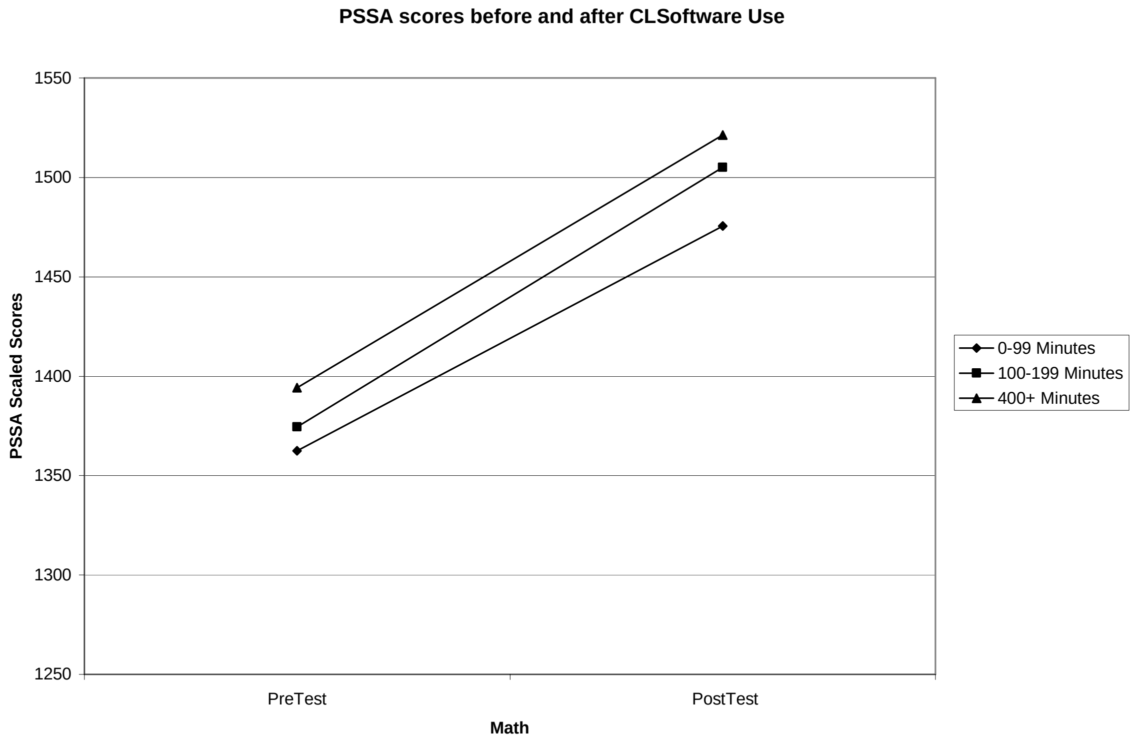

Figure 5. Posttest gains in mathematics as related to usage in Minutes per Month of CompassLearning software. It appears that increased time with the software led to increases in achievement gains among participants.

Unlike results for the same tests in reading, Figure 6 shows that there is a positive relationship between the number of minutes spent with individual activities and student achievement. Interestingly, groups with fewer minutes per activity showed greater gains than groups that spent more minutes on individual activities. This finding is consistent with the finding for reading: it appears that there is a point of diminishing returns in terms of the amount of time that students should spend with individual modules of the software.

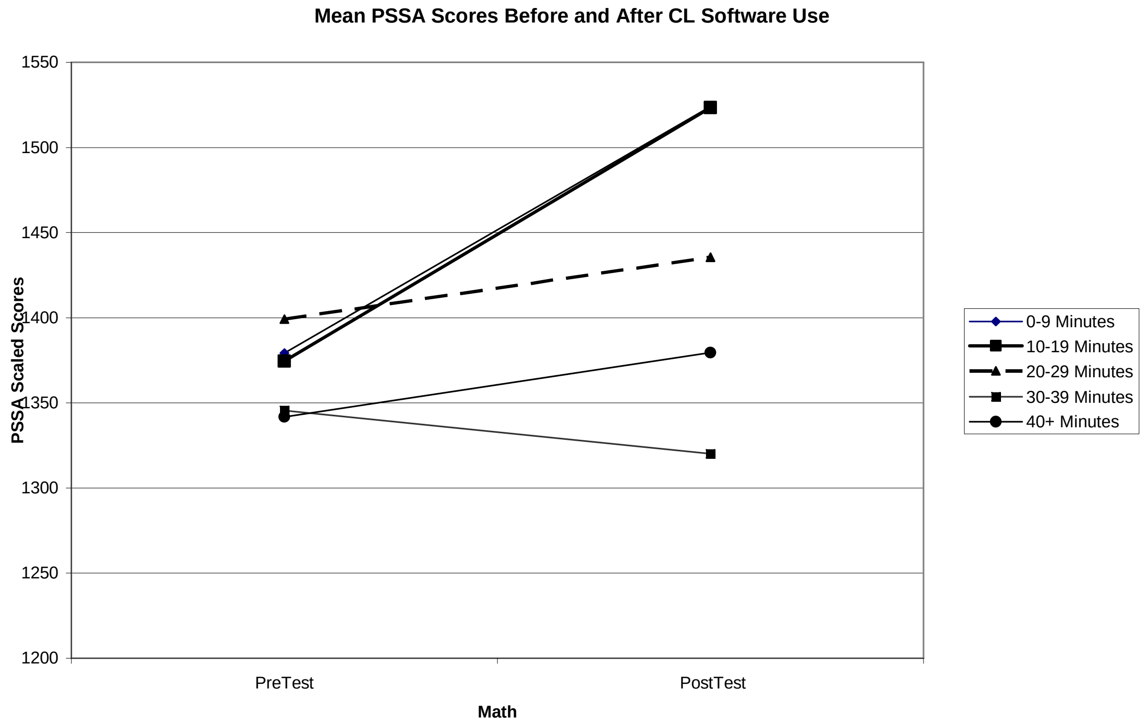

Figure 6. Posttest gains in mathematics as related to usage in Minutes per Activity of CompassLearning software. In all cases except 30-39 minutes, students showed gains in achievement based on minutes per activity.

Using Multivariate Tests(b), Table 14 shows that the Wilks' Lambda interaction among the variables of time and subject of was statistically significant (p<.01). The full table appears in Appendix J. As might be expected, students who used CLO mathematics software outperformed students who used the language arts software on the mathematics posttest. Groups that used either part of CLO software outperformed the group that used the CompassLearning server-based software.

Table 14

Wilks' Lambda: Correlation between Usage Groups, Time on Task in Mathematics, and Achievement

	Value	F	Hypothesis df	Error df	p
mathematics	.717	109.541(a)	1<.001	277<.001	<.001
mathematics * CLsubject	.829	28.510(a)	2<.001	277<.001	<.001

a Exact statistic
b Design: Intercept+CLsubject
Within Subjects Design: mathematics

Question Three

Is the change from pretest to posttest impacted by gender, SES, prior achievement level, or identification as students with special needs? While in the reading domain significance was found to exist among students based on prior achievement levels and IEPs, a different demographic variable appeared to influence mathematics achievement. Using a Test of Between-Subjects Effects, there was a statistically significant effect of SES on the impact of learning software on student mathematics achievement ($p<.05$). This finding, shown in Table 15, is consistent with results of other studies explored in Chapter II. It is reasonable to consider that children who do not qualify for free or reduced lunches might outperform students whose families have financial need. The full table related to this information can be found in Appendix K. Surprisingly, there was no significant interaction between Prior Achievement and achievement, nor was there a significant interaction between IEP and achievement.

Table 15

Correlation between Gender, SES, Prior Achievement, and IEP, and Mathematics Achievement

Source	Type III Sum of Squares	df	Mean Square	F	p
Corrected Model	347129.024(b)	8	43391.128	1.350	.219
Intercept	138067.784	1	138067.784	4.296	.039
Gr3RdgScaled	23912.404	1	23912.404	.744	.389
Gender	98078.731	1	98078.731	3.052	.082
SES	128975.171	1	128975.171	4.013	.046
IEP	32120.558	1	32120.558	.999	.318
Gender * SES	100984.779	1	100984.779	3.142	.077
Gender * IEP	53592.430	1	53592.430	1.667	.198
SES * IEP	53576.557	1	53576.557	1.667	.198
Gender * SES * IEP	88954.901	1	88954.901	2.768	.097
Error	8710099.419	271	32140.588		
Total	13277128<.001	280			
Corrected Total	9057228.443	279			

a Computed using alpha = .05
b R Squared = .038 (Adjusted R Squared = .010)

Summary of Findings Related to Mathematics

Based on the above discussion, the second null hypothesis, “There is no significant correlation between level of use of CompassLearning Odyssey mathematics software and PSSA mathematics scores,” is rejected. There is a significant positive correlation between levels of use of CompassLearning Odyssey software and student mathematics achievement. As expected, there is a higher correlation between mathematics usage and mathematics achievement than there is between language arts usage and mathematics achievement. A positive relationship exists between minutes of use per month, as well as minutes per activity, and mathematics achievement.

Based on the above findings, Hypothesis Number 4, “Gender has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software in PSSA achievement scores in mathematics,” is not rejected. This study found no relationship between gender and achievement gains; such a relationship, according to the studies examined in Chapter II, is only occasionally significant.

Unlike the findings for language arts, a significant correlation was found to exist between SES, the use of CompassLearning software and achievement. However, significance was limited to users of mathematics software. Therefore, Hypothesis Number 5, “SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading,” is not rejected. However, based on the interaction between SES and mathematics outcomes, Hypothesis Number 6, “SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics,” is rejected.

Hypothesis Number 8, “Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics,” is not rejected.

Contrary to findings for language arts, prior achievement levels, as evidenced by pretest scores, were not significantly correlated to posttest scores. Similarly, Hypothesis Number 10, which states, “Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics,” is not rejected. While no significant correlation was found to exist between identification as a student with special needs and achievement, it is important to recall that this study involved a comparison of the change from pretest to posttest. It is possible that further study from a different viewpoint might reveal ways in which educational software enhances achievement for this group of students.

Summary of Findings Related to Compass Learning Software

The first two null hypotheses of this study involved the assumption that CompassLearning Odyssey software would have no effect on student achievement in reading or mathematics. Both of these key hypotheses were rejected. This study supports the premise that CompassLearning Odyssey language arts and mathematics software enhance student achievement. Two findings, however, warrant further investigation. First, it is of value to learn whether or not the mathematics software consistently supports achievement gains in both mathematics and reading. A second area in need of further study is that of time on task with the software; educators and students alike would benefit from knowing the optimal duration for participation in computer-supported instruction and learning.

In terms of the remaining hypotheses about the demographic variables that might influence achievement, results were mixed. Gender had no effect on reading or mathematics achievement among all groups of users. SES showed a weak but significant relationship to mathematics achievement but not to reading achievement. Prior achievement levels (pretest) did have a significant effect on reading achievement among users of CLO language arts software but its effect was not significant for mathematics. Status as students with IEPs was a significant factor in reading achievement but not in mathematics achievement.

Regarding the ancillary question about the effect of varying amounts of time with technology on achievement, this study examined two aspects of usage: minutes per month and minutes per activity. In the case of students using language arts software, increased time per month had a positive effect on achievement. In apparent conflict with this finding, students who participated in individual activities for short periods of time showed greater achievement gains than did students who worked on single modules for extended periods of time.

For students using CompassLearning Odyssey’s mathematics software, increased time per month and time per activity led to improved achievement scores. Of interest is the fact that the reading scores of students who used only CLO mathematics software were higher than the reading scores of students who used only CLO language arts software. Further study is warranted to discern what elements of instruction or learning occur that might lead to such an outcome.

Post-Hoc Observations and Findings

This study showed disparate effect of CompassLearning Odyssey software between students who used the language arts software and those who used the mathematics software. It appeared that users of language arts software showed declines in reading achievement and modest gains in mathematics. Users of mathematics software showed gains in both reading and mathematics. Additional tests were conducted in an attempt to further define the relation between usage and achievement. The primary question to be answered in this post-hoc investigation was that of teacher effect of software usage. The next sections will discuss findings as they relate first to users of language arts software and then to users of mathematics software.

Language Arts Software Users

In order to understand the relationship between Minutes per Month and Minutes per Activity, a test of correlation was conducted. This test, illustrated in Table 16, revealed a significant correlation ($p<.001$) between the two variables. With this finding, it would have been possible to use only one of the two variables in a test of teacher effect on usage levels since, to a significant extent, they measure the same effect.

Table 16

Correlation between Minutes per Month and Minutes per Activity among Users of Language Arts Software

		Compass Minutes per Month	Compass Minutes per Activity
Compass Minutes per Month	Pearson Correlation	1	.536(**)
	p (2-tailed)		<.001
	N	82	82
Compass Minutes per Activity	Pearson Correlation	.536(**)	1
	p (2-tailed)	<.001	
	N	82	82

** Correlation is significant at the 0.01 level (2-tailed).

A one-way ANOVA was conducted between classrooms of language arts software users and Minutes per Month. Table 17 shows that there was no significant difference between groups in time spent with the software. This outcome supports the original finding that time spent with the software is inversely related to reading achievement. However, because other variables, not considered in this study, may also have affected results (e.g., the rigor with which teachers monitored student involvement with the software, the use of alternative online products), further investigation is warranted.

Table 17

Comparison of Minutes per Month between Classroom Groups of Language Arts Software Users

		Sum of Squares	df	Mean Square	F	p
Compass Minutes per Month	Between Groups	2.587	3	.862	1.928	.132
	Within Groups	34.889	78	.447		
	Total	37.476	81			
Compass Minutes per Activity	Between Groups	.043	3	.014	.584	.627
	Within Groups	1.908	78	.024		
	Total	1.951	81			

Mathematics Software Users

Similar to the post-hoc analysis for users of language arts software, a test of correlation was conducted in order to understand the relationship between Minutes per Month and Minutes per Activity among users of CompassLearning Odyssey mathematics software. This test, shown in Table 18, revealed no significance in the correlation between Minutes per Month and Minutes per Activity.

Table 18

Correlation between Minutes per Month and Minutes per Activity among Users of Mathematics Software

		Compass Minutes per Month	Compass Minutes per Activity
Compass Minutes per Month	Pearson Correlation	1	.166
	p (2-tailed)		.064
	N	125	125
Compass Minutes per Activity	Pearson Correlation	.166	1
	p (2-tailed)	.064	
	N	125	125

A one-way ANOVA was conducted between classrooms of mathematics software users and Minutes per Month. Table 19 shows that there was no significant correlation between groups in time spent with the software. This outcome supports the original finding that time spent with the software is positively related to mathematics achievement. However, because other variables, not considered in this study, may also have affected results (e.g., the rigor with which teachers monitored student involvement with the software, the use of alternative online products), further investigation is warranted.

Table 19

Comparison of Minutes per Month between Classroom Groups of Mathematics Software Use

		Sum of Squares	df	Mean Square	F	p.
Compass Minutes per Month	Between Groups	153.309	6	25.551	27.646	<.001
	Within Groups	109.059	118	.924		
	Total	262.368	124			
Compass Minutes per Session	Between Groups	6.185	6	1.031	9.642	<.001
	Within Groups	12.615	118	.107		
	Total	18.800	124			

This outcome led to questions about the influence of individual teacher behaviors in terms of the time that students spent with the software:

1. Was there a significant difference between individual teachers in terms of the amount of time that students accessed CompassLearning Odyssey mathematics software?
2. Did this difference lead to differences in achievement among users?

To discern the effect of usage levels based on membership in the classrooms of particular teachers, a test of correlation was conducted between these groups. After ranking classrooms of students by usage levels, it was possible to examine the relationship between Minutes per Month and achievement as measured by Grade Five PSSA posttest scores. Table 20 shows that there was no correlation based on this variable. A descriptive comparison of means related to Table 20 appears in Appendix L.

Table 20.

Correlation between Mathematics User Groups and Posttest Scores

		Teacher	Grade 5 PSSA Math
Teacher	Pearson Correlation	1	.141
	P (2-tailed)		.117
	N	125	125
Grade 5 PSSA Math	Pearson Correlation	.141	1
	P (2-tailed)	.117	
	N	125	125

Table 20 also showed that two groups stood out as having used the software significantly more than the other mathematics user groups. Upon removing these outlier groups from the test of correlation, it was found that indeed a positive correlation existed between levels of use and achievement. Table 21 shows that increased usage of CompassLearning Odyssey mathematics software led to significant gains on the PSSA posttest.

Table 21

Correlation between Mathematics User Groups and Posttest Scores after Adjusting for Outlier Groups

		Teacher	Grade 5 PSSA Math
Teacher	Pearson Correlation	1	.281(**)
	Sig. (2-tailed)		.006
	N	94	94
Grade 5 PSSA Math	Pearson Correlation	.281(**)	1
	Sig. (2-tailed)	.006	
	N	94	94

** Correlation is significant at the 0.01 level (2-tailed).

A positive relationship between usage levels and achievement appears to exist between CompassLearning Odyssey mathematics software. However, results may be confounded by teacher variables that were not part of this study. For this reason, this outcome warrants continued exploration.

Summary of Post-Hoc Findings

Post-hoc investigation into the relationship between usage levels of CompassLearning Odyssey software supports the initial findings of a significant negative relationship between language arts software usage and achievement, as well as a significant positive relationship between mathematics software usage and achievement. The addition of comparative analyses between individual groups of students and outcomes adds a level of confidence to these original outcome statements. At the same time, post-hoc tests revealed the importance of continued investigation into the possible effects of teacher variables on such outcomes.

The Relationship between 4Sight Assessments and PSSA Achievement

As discussed in Chapter I, 4Sight is a series of predictive assessments currently in use among public schools in Pennsylvania and elsewhere. The premise behind 4Sight is that the assessments accurately pinpoint areas of academic need among children as they prepare for the PSSA. Teachers can use data from 4Sight assessments to guide and differentiate instruction. Because the school district uses 4Sight assessments, a test of correlation was conducted between 4Sight's predicted scores and student posttest scores. The test shows a strong correlation between 4Sight predictive tests and PSSA achievement scores. An equally strong correlation between 4Sight pretests and posttests suggests that reliability exists between the 4Sight tests administered throughout the year.

4Sight Mathematics

All correlations between 4Sight mathematics pretests and posttests, as well as between 4Sight mathematics predictive scores and PSSA mathematics posttest scores are highly correlated at the .01 level. Specifically, 4Sight mathematics predicted scores are highly correlated with both the PSSA mathematics posttest (r = .554, p< .01) and with the 4Sight mathematics posttest (r = .763, p <.01). Table 22 illustrates this relationship.

Table 22

Correlation between 4Sight Mathematics Pretest and Posttest, and between 4Sight Mathematics Predictive Scores and PSSA Posttest Scores

		Grade 5				
		Mathematics Pretest Scaled Score	Mathematics PSSA (posttest) Scaled	4Sight Pretest Mathematics Percent	4Sight Posttest Mathematics Percent	4Sight Predicted Mathematics Scale Score
Mathematics Pretest Scaled Score	Pearson Correlation	1	.632(**)	.538(**)	.565(**)	.363(**)
	P (2-tailed)		<.001	<.001	<.001	<.001
	N	280	280	277	280	280
Grade 5 Mathematics PSSA (posttest) Scaled	Pearson Correlation	.632(**)	1	.581(**)	.751(**)	.554(**)
	P (2-tailed)	<.001		<.001	<.001	<.001
	N	280	280	277	280	280

Table 22 (continued)

4Sight Pretest Mathematics Percent	Pearson Correlation	.538(**)	.581(**)	1	.563(**)	.411(**)
	P (2-tailed)	<.001	<.001		<.001	<.001
	N	277	277	277	277	277
4Sight Posttest Mathematics Percent	Pearson Correlation	.565(**)	.751(**)	.563(**)	1	.763(**)
	P (2-tailed)	<.001	<.001	<.001		<.001
	N	280	280	277	280	280
4Sight Predicted Mathematics Scale Score	Pearson Correlation	.363(**)	.554(**)	.411(**)	.763(**)	1
	P (2-tailed)	<.001	<.001	<.001	<.001	
	N	280	280	277	280	280

** Correlation is significant at the 0.01 level (2-tailed).

4Sight Reading

All correlations between 4Sight Reading pretests and posttests, as well as between 4Sight Reading predictive scores and PSSA Reading posttest scores are significant at p<.01 (Table 23). The test shows that there is a strong correlation between the 4Sight predicted reading score and the 4Sight reading posttest (r=.551, p<.01). A similar correlation exists between the 4Sight Reading predicted score and the PSSA Reading posttest score (r=.540, p<.01).

Table 23

Correlation between 4Sight Reading Pretest and Posttest, and between 4Sight Reading Predictive Scores and PSSA Posttest Scores

		4Sight Posttest Rdg Percent	4Sight Predicted Rdg Scale Score	Grade 5 Rdg PSSA (posttest) Scale	4Sight Pretest Pdg Percent	Rdg Pretest Scaled Score
4Sight Posttest Rdg Percent	Pearson Correlation	1	.551(**)	.676(**)	.598(**)	.595(**)
	P (2-tailed)		<.001	<.001	<.001	<.001
	N	280	277	280	278	280
4Sight Predicted Rdg Scale Score	Pearson Correlation	.551(**)	1	.540(**)	.742(**)	.525(**)
	P (2-tailed)	<.001		<.001	<.001	<.001
	N	277	277	277	276	277

Table 23 (continued)

Grade 5 Rdg PSSA (posttest)	Pearson Correlation	.676(**)	.540(**)	1	.621(**)	.657(**)
Scale	P (2-tailed)	<.001	<.001		<.001	<.001
	N	280	277	280	278	280
4Sight Pretest Rdg Percent	Pearson Correlation	.598(**)	.742(**)	.621(**)	1	.615(**)
	P (2-tailed)	<.001	<.001	<.001		<.001
	N	278	276	278	278	278
Rdg Pretest Scaled Score	Pearson Correlation	.595(**)	.525(**)	.657(**)	.615(**)	1
	P (2-tailed)	<.001	<.001	<.001	<.001	
	N	280	277	280	278	280

** Correlation is significant at the 0.01 level (2-tailed).

Table 23 shows that correlations are significant at the p< .01. Specifically, there is a strong correlation between the 4Sight reading predicted score and the 4Sight reading posttest score ($r = .551$, $p < .01$), indicating that the 4Sight reading tests reliably reflect common objectives and degrees of difficulty. There is a similarly strong correlation between the 4Sight predicted reading score and the PSSA posttest reading score ($r = .540$, $p < .01$). This indicates that the 4Sight assessments are able to accurately identify areas of academic need as teachers and students prepare for the PSSA.

Chapter Summary

Having conducted descriptive statistical analysis of the three groups of participants, it was determined that members of each group did not differ significantly. For this reason, the study included students with the following levels of access to CompassLearning software: web-based language arts only, web-based mathematics only, and CompassLearning’s server-based software. Through the use of independent t-tests, ANCOVA Multivariate Tests and Between-Subjects Effects Tests, analyses were conducted to determine the relationship between use of CompassLearning software and achievement as measured by the PSSA.

There is a significant relationship between the use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement. The relationship, however, appears to be rather one-sided as students in the mathematics group outscored students in the language arts group on the PSSA reading posttest. Both of these groups did better than the group that used CompassLearning’s server-based software. The limited success experienced by users in the server-based group might be attributable to several factors: boredom with a familiar self-contained product on the part of the students or disinterest among teachers in the only school in the district that had not integrated the online version of CompassLearning.

While the above results are significant, the unexpected difference in outcomes between users of either language arts or mathematics software led to further post-hoc analyses. This activity highlighted the need for further exploration of teacher-related behaviors that might influence outcomes.

Gender is the only demographic variable in this study that appeared to have no effect on either reading or mathematics achievement among the groups in this study. Socioeconomic status was significantly correlated to mathematics achievement. Conversely, prior achievement and identification as students with special needs were significantly correlated only to reading achievement.

This study, while affirming the value of CompassLearning Odyssey software, generates additional areas of interest to researchers. First, there is a need to examine the relationship between the time spent using educational software and achievement. Based on the findings of this study, there seems to be a point of reversal in terms of time spent using educational software. Of particular value to teachers and students would be the identification of the appropriate amounts of time on task that optimize learning.

Another area in need of further explanation is the finding in this study that, on both the reading and mathematics PSSA posttests, students who used CLO mathematics software performed better than their counterparts who used CLO language arts software.

Having conducted analyses of the effects of CompassLearning Odyssey software on student achievement, Chapter V will expand on the results as they relate to current research. Based on that discussion, recommendations will be made in terms of future studies of educational software.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This dissertation studied the relationship between a specific language arts and mathematics software program and student achievement. The software under study was CompassLearning Odyssey, a web-based tool used by schools across the United States. Because the product is widely used across Pennsylvania, and because there is limited research-based evidence as to its efficacy, this study of CompassLearning Odyssey is both timely and helpful to educators.

A brief overview of the study's results as they relate to the research discussed in Chapter II will be followed by a discussion of areas in need of further research.

Overview of Findings

The purpose of this study was to compare usage levels of CompassLearning Odyssey mathematics and language arts software among fifth grade students in order to determine the relationship between usage and achievement. Results showed a significant relationship between CompassLearning Odyssey language arts and mathematics software and achievement as measured on the Pennsylvania System of School Assessment (PSSA).

Summary of Hypotheses Outcomes

The first two null hypotheses of this study involved the ability of CompassLearning Odyssey to enhance student achievement:

1. There is no significant correlation between level of use of CompassLearning Odyssey language arts software and PSSA reading scores.

2. There is no significant correlation between level of use of CompassLearning Odyssey mathematics software and PSSA reading scores.

Results showed that a significant correlation exists between CompassLearning Odyssey language arts and mathematics software and achievement on the PSSA reading and mathematics subtests. Thus the first and second null hypotheses were not rejected. However, the correlation between CLO language arts software and reading achievement is a negative one. Further, though not as surprising, students who used language arts software made less significant gains on the mathematics posttest than did students who used the mathematics software. Significant positive effect between CLO mathematics software and PSSA posttests rests among users of mathematics software. Members of this group showed greater gains on the PSSA reading and mathematics subtests than did either of the two other groups (language arts users and users of CompassLearning's server-based software).

The surprising element in this analysis was that usage of CompassLearning Odyssey language arts software appears to have had a deleterious effect on reading achievement and only a modest positive effect on mathematics achievement. A number of factors may influence such an outcome. First is the general delivery of instruction in a computer-based setting. Generally, students use instructional software at their own pace and with little intervention by their teachers (Kinzie & Milbrath, 2002). It is possible that such a self-directed environment is less effective with language arts than with mathematics activities.

It may also be that teachers themselves are able to support computer-based mathematics instruction more effectively than they can language arts instruction. For example, the reading activities and stories covered in CLO may or may not parallel those used in the classroom. This being the case, it may be that there are fewer opportunities for teachers to use computerized instruction to teach and reinforce the scope and sequence of daily language arts lessons in the classroom. Mathematics, on the other hand, is a more linear process of instruction: skills for fifth grade mathematics are more easily defined and targeted across classroom and computer-based instruction.

The results described here formed the foundation for further investigation into the effect of belonging to specific classrooms on levels of use. While no significant difference was shown to exist between groups of language arts software users, there was a difference in usage levels among mathematics software users. This discovery underscores the need for further exploration into teacher behaviors that might influence the ability of instructional software to enhance achievement.

In this study, a third group used both the language arts and the mathematics components of CompassLearning's server-based product. The reading pretest scores of this group were slightly higher than the reading pretest scores of the other two groups, but posttest scores were about the same between this group and the reading group. This indicates a greater decline in performance for this group than for either of the other two groups. In mathematics, the pretest scores of all three groups were relatively similar, yet the posttest scores for the students who used the server-based product showed fewer gains on the posttest. This may be the result of more than one factor. First, since School A was the only one of ten elementary schools that was still using the server-based software, teacher and student attitudes toward the software may have skewed results. Both teachers and students may have approached their time with the software, with which they were quite familiar, with less enthusiasm and rigor than they might have if the software had been new to them. Recalling that a primary advantage to computer-based instruction is its ability to engage the interest of the learner, it should be noted that, at the time of this study, CompassLearning's server-based product was no longer supported by the company in terms of upgrades in content or appearance.

The third and fourth null hypotheses addressed the effect that gender might have had on achievement:

3. Gender has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
4. Gender has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.

This study found that there was no significant relationship between gender and achievement outcomes with the use of CompassLearning Odyssey software. Thus both the third and fourth null hypotheses were not rejected. This finding is in keeping with current research that indicates the limited presence of gender as an influencer of achievement as it relates to technology use among elementary age children. According to the literature, gender differences tend to appear during students' high school years; many researchers find that, despite high home use of computers, high school age girls show diminished skills and interest in technology in the school setting. This anomaly is often attributed to two factors: first that the majority of secondary teachers involved in technology-related classes like computer science and mathematics are male; a second factor, according to studies, is that teenage girls choose to either hide or underplay their skills and interest in male-dominated subjects in order to gain popularity and acceptance by both male and female peers.

The fifth and sixth null hypotheses explored the relationship between socioeconomic status and achievement gains within the context of CompassLearning software:

5. SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
6. SES has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.

In this case, SES had a significant effect on the relationship between the use of mathematics software and PSSA achievement. Among this group, the achievement gains experienced by children who did not qualify for free or reduced lunch were greater than those among children who did qualify for free or reduced lunch. However, a similar effect was not noted among users of language arts software. Thus, the fifth null hypothesis was not rejected while the sixth null hypothesis was rejected.

Because the findings of this study show an SES effect only among users of mathematics software, the outcomes of this study differ from similar research on the effect of SES on achievement (Jarrell, 2000; Newcombe, 2005; Palmer, 2001; Rose, 1997). Other studies revealed no differentiation in the effect of language arts and mathematics software usage on achievement. However, two important considerations must be made. First, other studies focused on either language arts or mathematics; there was little comparison of the interplay between SES, type and duration of software usage, and achievement. Analysis of studies across subject areas might yield results similar to the ones discerned in this research. Another issue relates to the fact that, in this study, use of language arts software had a negative effect on achievement. Within studies that show a positive correlation between software use and achievement, the effect of SES may be more significant and more similar to the findings of current literature.

The seventh and eighth null hypotheses focused on the effect of prior achievement levels (scores on a pretest) on achievement gains:

7. Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.
8. Previous achievement levels have no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.

In contract to the effect of SES, the effect of prior achievement on posttest scores was significant only among users of language arts software. Thus, the seventh null hypothesis is rejected while the eighth null hypothesis is not rejected. It appears that, among language arts software users, a greater gain was experienced by students whose pretest scores were higher than the pretest scores of other students. The significance of this finding is that it may imply a predetermined learning curve for students. In other words, it may be that the rate of growth experienced among young learners is one that follows them throughout their lives. If this is the case, teachers are challenged to boost the learning curve at the early stages of education in order to foster more rapid rates of learning over the course of their students' educational careers. Of particular note is that, because this study showed significant effect of prior achievement level on the relationship between computer usage and achievement, there is evidence that computer-based instruction has the potential to assist in the effort to increase the rate of learning among children. Such use of computers is supported by cognitive, constructivist, and social capital theorists who suggest that technology in schools can provide equity in learning opportunities for all learners.

It is also possible that the students with higher pretest scores possessed reading and mathematics skills that enabled them to interact successfully with the learning software. Moreover, with better command of basic skills and knowledge, these students might have been better able to work with instructional tools that, while interactive in nature, require learners to work independently. This finding serves as evidence that there is a need to promote equitable access to rich learning opportunities for all students. For the sake of narrowing the gap between learners without lowering overall expectations, educators should carefully design appropriate and meaningful instruction for students in the early years of their educational careers.

The final two null hypotheses addressed the effect that identification as learners with special needs had on achievement in reading and mathematics:

9. Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in reading.

10. Status as children with or without Individualized Education Plans (IEPs) has no significant effect on the correlation between level of use of CompassLearning Odyssey language arts and mathematics software and PSSA achievement scores in mathematics.

Significance was shown to exist in the relationship between learners with special needs and achievement only in the area of reading. This relationship meant that children with IEPs show significantly fewer gains on the PSSA reading subtest than did students without IEPs. In other words, among language arts software users, there was a significant negative correlation between PSSA reading scores and whether or not children had IEPs. In the area of mathematics, the rate of change from pretest to posttest was not affected by status as children with specific learning disabilities. Thus, the ninth null hypothesis was rejected while the tenth null hypothesis was not rejected.

In this study the phrase, “identification as students with special needs,” was limited to those students with specific learning disabilities. Children with hearing or speech impairment were not part of this definition, nor were students identified as being gifted or talented. Given this fact, it seemed likely that significant effect would have been found in both reading and mathematics achievement. More careful consideration leads to a realization that there may be several plausible reasons for this unexpected outcome. First is the fact that a majority of specific learning disabilities involve some form of reading difficulty. Generally, students with IEPs perform better in mathematics-related tasks than in those related to reading; it is far more likely that Individualized Education Plans will include accommodations for reading than for mathematics. It is therefore reasonable to consider that greater effect would be seen in reading achievement than in mathematics achievement. While reading skills are needed on the PSSA mathematics subtest, students with learning disabilities can generally perform more of the required tasks on this assessment than on the reading subtest of the PSSA.

Another consideration directly related to this study is the fact that CompassLearning Odyssey language arts software was found to be negatively correlated with achievement. At the same time, CLO mathematics software was positively correlated with achievement. This disparity may have served to both amplify the relationship between possession of an IEP and reading achievement, and to dull the relationship between possession of an IEP and mathematics achievement. In addition to findings specific to this software it may be that in general, while language arts software-based instruction requires users to read descriptions and instructions, the format of mathematics software is less reading-intensive and therefore more successful as an instructional medium for students with learning disabilities.

A final consideration relates to the suggestion made earlier that rates of academic growth vary among students. This difference is more evident when comparing students with and without IEPs. While the ideal purpose of IEPs is to support students in ways that allow them to catch up with their peers and gain the skills needed to perform successfully at grade level, a more common function is to accommodate learners with special needs in ways that actually slow the acquisition of skills. Referring again to the rate of learning or "learning curve" that varies among students, it is possible that similar studies might yield similar results: students with specific learning disabilities may show consistently less achievement effect from language arts software instruction than they do with mathematics software instruction.

Considerations Related to this Study

This study yielded results that are consistent with current literature. As with all research involving human subjects, there are elements beyond the control of the researcher. For the sake of accuracy in reporting, and to support future research, it is necessary to note such elements. The following sections detail some of the characteristics of this study that may have influenced outcomes.

Use of Technology outside the Parameters of CompassLearning Software

Groups of students and their teachers were assigned to use specific portions of CompassLearning Odyssey. However, there was no concurrent mandate to avoid other technology solutions. For example, a class that had been assigned to use no CLO mathematics activities had not been told to avoid all types of online language arts instructional activities. Like other school districts, the district in this study pays for one primary software solution. Yet teachers and students had the freedom to use online tools during their time with computers. There is no way to measure the extent to which this occurred among any of the groups of classes. It is possible that technology-based instruction and learning occurred outside of the current study; depending on the content area(s) in use, achievement gains may be partially attributable to sources other than CompassLearning software.

Size of the Study

The research conducted in the study site involved 280 fifth grade students in five elementary schools. As a consequence of being sorted into three user groups, and then being further clustered according to demographic variables, the IEP variable had a small number of participants. It is possible that a larger study would yield more definitive results in areas that showed narrow margins of significance. These areas include both IEP and SES. In addition to using a larger pool of participants, a desirable area of expansion might be the inclusion of additional grade levels, particularly since the PSSA is currently being administered to more grade levels than ever before. Another option might be to design a study around students across multiple school districts; such a plan might more effectively show the varying influence of variables such as school policy and teacher practices on student outcomes.

Focus of the Study

This study focused on student behaviors related to the use of instructional software. Therefore, although research points to such issues as teacher age, attitude, and perceptions of access and ability as significant determinants of the success of software interventions, it was necessary to exclude variables related to teachers from this work. Other studies show that teacher perspectives and behaviors can impact the effect of technology on student achievement. In the case of this research, participating teachers and students were afforded comparable time with technology. Nevertheless, as a result of the variables mentioned here, certain teachers may have felt less confident and supported in the implementation of technology than others.

Student Characteristics Not Addressed in This Study

One demographic not considered in this study was ethnicity. With an overall minority population of four percent, the study included 15 (5.36% of the subject population) non-European White children. It is possible that ethnicity, when combined with SES and other variables, would have yielded further insight into the relationship between technology use and achievement.

Relationships between this Study and Current Literature

In order to understand trends in technology-based education, Chapter II described research that explored topics similar to the ones of interest in the current study. Of the studies related to technology-based instruction, the preferred subject for exploration related more to language arts (reading, writing, or vocabulary) than to mathematics. Below is a description of the variables examined in the current study and the ways in which they relate to the studies discussed in the review of the literature.

Time with Technology

According to Norris, Sullivan, Poirot, and Sullivan (2003), increased time with technology leads to greater achievement gains. In the current study, this outcome is not a certainty. Instead, it appears as if there is a point at which achievement may actually decline as a result of extended time with technology. It may be that technology use is less the cause of this outcome than the consequence of lost traditional instructional time that comes with long periods of time with technology. More in keeping with the findings of this dissertation is Jarrell's (2000) conclusion that time on task with technology has varying effects on achievement. Of course, as with all instructional activities, there is a need to distinguish "time on task" from "meaningful time on task."

A common premise among research related to time spent with technology is that the level of active engagement demonstrated by students during computer-based activities raises achievement. If this common proposition is accurate, it may follow that too much time with technology would have a dulling effect on achievement. This idea supports the finding of the current study that there seems to be a point of diminishing return in the relationship between time with technology and achievement. Further research in this area may reveal whether this outcome is the result of diminished focus or interest during the use of software-based instruction, the lack of direct intervention when students reach an impasse in their understanding of the material being taught via the technology, or some other variable.

Gender

The findings of this dissertation are in keeping with the findings of a study by Rose (1997) in which gender in isolation did not significantly affect student achievement.,] Rose did discover, however, that gender, coupled with SES, led to significance in that male students of low SES showed fewer gains than female students of low SES. Similarly, Bohannon (1998) found that boys made significant achievement gains when afforded 1:1 access to computers; no significance was found when two students shared one computer. In both cases, girls showed no significant gains.

SES and Identification as Students with Special Needs

Bohannon (1998) and Perez (1997) found that students of low socioeconomic status showed greater gains through the use of technology than other students. The authors attribute this finding to the fact that technology enables members of this population, who often lack home access to computers, to catch up with their non-disadvantaged peers. A difference between these studies and the current one is that the authors above included the variable of ethnicity in their studies. While much of the research focused on poverty as a factor in the correlation between technology use and achievement, the study of fifth graders in the current study site found the effect to be limited to students who used mathematics software. Students of low SES who used CLO mathematics software indeed showed significant gains on the PSSA posttest in comparison with other groups.

Palmer (2001) suggests that achievement gaps based on technology use disappear when access is equitable to all learners. She postulates that the variables of SES and identification as learners with special needs become irrelevant when all students receive the same type of access and high-level instruction. In the case of the current study, access to technology and the type of activities assigned to students was somewhat controlled by the use of CompassLearning Odyssey software. The modest significance levels in some categories support Palmer’s argument.

Prior Achievement

Generally, studies that examined prior achievement as a factor in the rate of achievement growth through technology found that at-risk students benefited more from technology than did others who were accustomed to using computers in school and at home. Among students in this study, the only significance was found among users of language arts software. Mintz (2000) drew similar conclusions based on a study of the effect of technology on SAT-9 scores. Students with higher SAT-9 scores at the start of the study showed the only significant gains. In keeping with the suggestion that technology-based instruction and learning are language-dependent, evidence of significant gains based on prior achievement levels is particularly encouraging. There is substantial value in using technology as an instructional tool if it can indeed accelerate the rate at which new learning is gained among students whose prior achievement had been lower than that of their peers. Such a circumstance would empower all learners to achieve to higher levels.

A study by Ritchie (1999) suggests that attitude toward technology is a major factor in whether or not prior achievement levels impact the effect of software on changes in achievement from pretest to posttest. The author states that students who had experienced frustration with technology showed little growth while those who had no problems while using the software seemed to show more significant gains. This being the case, it is possible that the most effective technology interventions are those that are well-supported by knowledgeable teachers and technicians. Such findings support other research that explores the effect of teacher behaviors and attitudes toward technology on student achievement outcomes.

Variables that influence the outcomes of educational studies are myriad. Even as one hypothesis about the effects of technology-based instruction and learning is verified through multiple studies, additional issues arise. After relating the findings of the current study to those of other researchers, there appear to be significant gaps in the study of technology and its effect on student achievement. The following section will discuss areas in need of further exploration.

Recommendations for Further Study

This study of the effect of CompassLearning Odyssey language arts and mathematics software supports the hypothesis that educational software enhances student achievement. There is value in this study as it examined the ability of one software system to support and enhance student achievement. However, the knowledge that CompassLearning Odyssey language arts and mathematics software tools indeed lead to varying gains in student achievement is but the beginning of meaningful research. As with most studies, some findings provide fodder for further exploration. Outlined below are some of the questions that arose as this study unfolded.

How does CompassLearning Odyssey Compare to Other Software Tools?

As a standalone study this research—and others like it—does not allow end users to accurately compare CompassLearning tools with other products. One reason is that studies of this nature are conducted within particular settings and with groups of subjects whose demographics may or may not match those of participants in other studies. Of exceptional value to users of such software might be similar research that involves multiple products within the framework of a single study. Such an endeavor would allow for direct comparison of the strengths of specific educational technology tools. In that most school districts purchase one primary software product, research of this nature would involve a collaborative effort across school districts. While it may be a project beyond the scope of a doctoral dissertation, a controlled cross-product study would yield substantial financial and educational benefits for researchers, school districts, teachers, and learners.

What Teacher Variables Support Achievement Gains through the use of Instructional Technology?

Given the fact that this study showed differences in student achievement between groups of users, it can be deduced that teacher variables affect outcomes. Teachers vary in the ways in which they interact with students and the learning process during time with technology. Some may more effectively monitor or control student engagement. Some may make better use of the reporting systems available through the software in order to coordinate learning events between computer time and times of direct instruction. Still other teacher variables may influence the power of technology software as instructional tools. For this reason, there is a need for additional investigation into teacher behaviors before, during, and after the use of instructional software.

What Technology Tools and Strategies Accelerate the Rate of Learning among Young Students?

The results of this study showed that users of the mathematics-only portion of the CompassLearning Odyssey software fared better on the reading posttest than did users of the language arts -only software. Further study is needed in order to support and advance understanding of this phenomenon or to refute it. It is possible that, because interaction with most software-based instruction is language-based, learners gain reading and comprehension skills as they complete mathematics activities. However, the same can be said for technology-based language arts instructional software. Future study might explore the significance of differences in achievement gains between technology-based instruction across subject areas.

Is there a Relationship between Mathematics Software and Gains in other Areas such as Reading or Language Arts?

Because users of mathematics-only CompassLearning Odyssey software outperformed users of language arts-only software even on the reading portion of the PSSA posttest, it may benefit future researchers to learn whether or not this is a replicable outcome. One possibility is that that CompassLearning Odyssey's language arts software is less effective than is its mathematics software. Another possible explanation is that the correlation between CLO's mathematics product and the PSSA mathematics subtest is stronger than the correlation between CLO's language arts program and the PSSA reading subtest. A third reason for this outcome may be that technology-based mathematics instruction is inherently more effective than technology-based language arts instruction. Additional research might provide insight into questions related to all of the above possibilities.

What is the Relationship between Time on Task and Effective Technology-Based Instruction?

In this study, there appeared to be incompatible points of interest related to the time spent using technology-based software. On one hand, students who used technology for 400 minutes or more each month appeared to do better on the posttest. On the other hand, students who spent the shortest amount of time on individual activities appeared to show greater gains between the pretest and posttest of this study. Given these apparently incongruous effects, it is possible that additional research will shed light on time-related elements of technology-based instruction that lead to optimal learning. At issue is the cause of such effects; with knowledge about the break-even point in technology use—which may vary by subject area—student achievement scores might show more significant and positive effects of technology use on achievement.

Is there a Significant Difference in the Effect of SES on Language Arts versus Mathematics?

In this study, a significant relationship between socioeconomic status and achievement existed only for the users of mathematics software. The size of this study, coupled with the fact that the greatest significance overall was seen among users of mathematics software, might have influenced the one-sided correlation between SES and achievement. This finding is not in evidence among the studies explored in Chapter II. It is possible that limited or no studies have compared the varying effect of SES on mathematics versus language arts achievement. It is also possible that a form of meta-analysis might construct such information from existing studies.

Within Specific Software Products, is there a Significant Difference in the Effect of SES on Language Arts versus Mathematics?

Related to the above query, there is a need to examine all of the offerings of particular software providers within the context of a single study. For two valid reasons, districts often buy all of the software packages available through a single vendor. First, there is a savings both in terms of actual cost and in terms of teacher training. It is cost-prohibitive o provide the infrastructure, technical support, and professional development needed to successfully implement multiple software platforms. Additionally, school districts often base purchasing decisions on the premise that, if one part of the program shows outstanding results, it is likely that all elements are equally effective. This study shows that such assumptions may be ill-founded. To the benefit of districts that spend money on technology interventions, and ultimately to the students in their care, examining the efficacy of more than one aspect of a vendor’s offerings within the context of a single study would provide a comprehensive and accurate view of the ability of separate pieces of a technology product to achieve desired results.

Recommendations for Practice

Based on the results of this study, and bearing in mind the relationship between this and the findings of related literature, there are a number of issues that should be considered by educators involved in the integration and implementation of software-mediated teaching and learning. The following sections will offer suggestions for practitioners in the areas of implementing and supporting technology software in the elementary setting.

Implementation of Educational Technology Software

First, while technology has the power to enhance achievement, its benefits are not a guarantee. Rather, the ways in which software is implemented appear to affect student outcomes when using technology. In this study, time on task was correlated to gains in achievement. Spending more time with technology led to greater gains. At the same time, there is evidence that spending shorter amounts of time with individual activities is equally beneficial. These facts suggest that practitioners might optimize the effect of technology on achievement by first providing students with appropriate amounts of time to use technology software and then by encouraging students to participate actively in the software-based lesson in order to complete individual activities in short amounts of time.

Teacher Issues Related to the Use of Educational Technology Software

This study did not directly address teacher attributes as factors in the ability of technology to boost student achievement. Nevertheless, there are two areas related to teachers that were brought to light through this research. First is the fact that the ways in which students interact with the software (brief versus lengthy time with individual activities) affect achievement gains. This finding indicates that learners may benefit when teachers monitor student levels of engagement while using technology software. Of course, in order for teachers to monitor and intervene effectively, it may be necessary to support them in staying current with research related to technology-based instruction.

The second consideration relates to the first in that action research within the instructional setting may be one of the most effective ways of optimizing the positive effect of technology on learning. Data for this study were gathered directly from reports available within the software program. With appropriate support and expectations, it is possible for teachers to discern the effect of software on student outcomes within their specific setting. Conducting such internal checks will allow teachers to tweak their delivery of the software to the best advantage of their students.

Chapter Summary

As much as computers have become a part of mainstream life in industrialized nations, debate continues over the efficacy of computers and other technology as tools for enhancing achievement among schoolchildren. Nevertheless, computers are integral to most classrooms in the United States. Although high costs are associated with upgrades and maintenance of infrastructure, hardware, and software, money is not the primary criticism of technology in education. Of greater concern is the often conflicting information about the power of technology to transform education. Until recently, many of the reports about the effect of specific software tools on achievement had been the product of the vendors whose companies developed the products.

New Developments in Research

With NCLB came more strident demands for research-based reports about specific technology tools. Increasing numbers of doctoral studies and data-driven reports are emerging that speak realistically about the ability of technology to "reach and teach" today's learners. The What Works Clearinghouse is one example of the way in which agencies attempt to make this information available to end users of educational technology.

These activities have bolstered the confidence of those involved in the implementation of technology in education. Even so, there is ample room for exploration into the nuances of effective technology-based instruction. This is particularly true in the face of educational evolution based on political tides, innovations in technology, and the changing needs of students and families.

In conjunction with the studies described in Chapter II, the current study supports theories that claim technology is an effective tool for teaching and learning. From behaviorism to cognitivism to constructivism, technology is most often seen as a harbinger of a global learning community. This is not to say that computers and other forms of technology are a panacea for the ills that beset education. However, the potential of technology to invigorate both teacher and learner exists. The continuation of research and a willingness to modify practices based on findings will bode well for the success of learning software in enhancing achievement for all learners.

CompassLearning Odyssey

This study explored the effectiveness of CompassLearning Odyssey's language arts and mathematics software in enhancing student achievement on the state's standardized assessment. As with similar research projects, some elements of the program appeared to be more effective than others. Exposure of this fact, as well as conjecture about the possible cause of such outcomes, should be viewed as a way for all participants in the integration of educational technology to improve on current practices for the ultimate benefit of learners. Software providers benefit from information that provides guidance in the improvement of software to higher levels of effectiveness.

School districts and implementers of instructional technology gain in their understanding about the ways in which technology should be used to maximize results.

The Future of Research in Educational Technology

Questions in need of further investigation relate primarily to the variables that have the potential to skew the outcome of educational studies: student characteristics, attitudes among teachers, administrators, and the public, as well as other unforeseen factors that occur during the course of a research project. In addition to these regularly occurring anomalies, studies are themselves often the victim of the system they attempt to analyze. By the nature of education, studies are often confined to one or two school years; the political landscape that drives educational decisions has the potential to change every four years, leading to abrupt reallocation of funding for technology, research, and other endeavors.

Despite such challenges, today’s growing body of knowledge about educational technology and the concurrent opportunity for schools to access such knowledge are two reasons for optimism regarding the ability of technology to enhance achievement for all learners.

References

Alderman, M. K. (1999). *Motivation for achievement: Possibilities for teaching and learning.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Atkins, N. E., & Vasu, E. S. (2000). Measuring knowledge of technology usage and stages of concern about computing: A study of middle school teachers. *Journal of Technology and Teacher Education, 8*(4), 279-302.

Bailey, J. (2004). Making the case: Research efforts on educational technology: A closer look at scientifically based research. *T.H.E. Journal, 31*(10), 36-40.

Baker, E. L., & O'Neil, H. F. (1994). *Technology assessment in education and training.* Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Barnett, L. B. (2006). The effect of computer-assisted instruction on the reading skills of emergent readers. *Dissertation Abstracts International, 67* (01), 130A. (UMI No. 3202829)

Becker, H. J. (2000). Who's wired and who's not: Children's access to and use of computer technology. *The Future of Children, 10*(2), 44-75.

Benz, C. R. (1998). *The qualitative-quantitative research methodology: Exploring the interactive continuum.* Carbondale, IL: Southern Illinois University Press.

Bogle, L. R. (2000). Technology, instructional change, and the effect on reading achievement. *Dissertation Abstracts International, 61* (11), 4346A. (UMI No. 9995662)

Bohannon, H. G. (1998). The relationship between frequency of computer use and student performance among fifth grade students. *Dissertation Abstracts International, 59* (03), 709A. (UMI No. 9827812)

Boudourides, M. A. (2003). Constructivism, Education, Science, and Technology. *Canadian Journal of Learning and Technology, 29*(3). Retrieved June 10, 2005, from http://www.cjlt.ca/content/vol29.3/cjlt29-3_art1.html

Byers, C., & Byers, W. A. (1998). *Sliding scale: A technique to optimize the assessment of knowledge level through ordering theory.* Paper presented at the Annual Conference of the International Personnel Management Association Assessment Council, Chicago. Retrieved October 5, 2006, from http://www.ipmaac.org/conf/98byers.pdf#search=%22hierarchical%20learning%20gagne%22

Campbell, J. P. (2000). A comparison of computerized and traditional instruction in the area of elementary reading. *Dissertation Abstracts International, 61* (03), 952A. (UMI No. 9966683)

Chung, J. (2002). The effect of the availability of technology on teachers' use of technology and student achievement on standardized tests. *Dissertation Abstracts International, 64* (01), 32A. (UMI No. 30077579)

Cohen, L, Manion, L., & Morrison, K. (2000). *Research methods in education*. London: Routledge Falmer.

Connolly, S. C. (2005). Kids and computers: The interactions and attitudes of girls and boys with technology. *Dissertation Abstracts International-A (66/12), 4359.* (UMI No. 3200612)

Cross, C. T. (2004). *Political education: National policy comes of age.* New York: Teachers College Press.

Cuban, L. (1986). *Teachers and machines: The classroom use of technology since 1920.* New York: Teachers College Press.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom.* Boston: President and Fellows of Harvard College.

Current Population Survey, October 1997 and October 2003[Data file]. Washington, DC: Census Bureau, U.S. Department of Commerce.

DeBell, M., & Chapman, C. (2006). *Computer and Internet Use by Students in 2003* (NCES 2006-065). U.S. Department of Education. Washington, DC: National Center for Education Statistics.

Digest of Education Statistics (2004). *Percent of home computer users using specific applications, by selected characteristics: 1997 and 2003.* U. S. Department of Education: National Center for Education Statistics.

Dubow, E. F., & Ippolito, M. F. (1994). Effects of poverty and quality of the home environment on changes in the academic and behavioral adjustment of elementary school-age children. *Journal of Clinical Child Psychology, 23*(4), 412-423.

Dugard, P., & Todman, J. B. (2001). *Single-case and small-N experimental designs: A practical guide to randomization tests.* Mahwah, NJ: Lawrence Erlbaum Associates.

Duffy, T. M. & Jonassen, D. H. (Eds.) (1992). *Constructivism and the technology of instruction: A conversation.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Feuer, M., &Towne, L. (2006, February 6). The logic and the basic principles of scientific based research. *Proceedings of a Working Group Conference, U.S. Department of Education: The use of scientifically based research in education.*

Retrieved October 18, 2006, from http://www.ed.gov/nclb/methods/whatworks/research/page_pg4.html

Fields, V. F. (2004). The relationships of teachers' levels of technology integration on student achievement in reading and mathematics. *Dissertation Abstracts International 65* (09), 3263A. (UMI No. 3148956)

FitzPatrick, S. B. (2001). An exploratory study of the implementation of an educational technology in two eighth grade mathematics classes. *Dissertation Abstracts International, 62* (06), 2082A. (UMI No. 3016646)

Gagné, R. M. (Ed.). (1987). *Instructional technology: Foundations.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Gance, S. (2002). Are constructivism and computer-based learning environments incompatible? *Journal of the Association for History and Computing, V*(1). Retrieved June 13, 2006, from http://mcel.pacificu.edu/JAHC/JAHCV1/K-12/gance.html

Glennan, T. K. (1996). *Fostering the use of educational technology: Elements of a national strategy.* Santa Monica, CA: Rand.

Goals 2000: Educate America Act, 103rd Congress, 2d Sess. (1994). Retrieved April 23, 2005, from http://www.ed.gov/legislation/GOALS2000/TheAct/index.html

Goddard, M. (2002). What do we do with these computers? Reflections on technology in the classroom. *Journal of Research on Technology in Education, 35*(1), 19-24.

Groundwater-Smith, S. (2004). *Serving different master? Relating evidence to policy and practice in the provision of services.* Paper presented at the EARJ Invited Seminar, London.

Hall, P. A. (2004). Great Britain: The role of government and the distribution of social capital. In R. Putnam (Ed.), *Democracies in flux: The evolution of social capital in contemporary society* (pp. 21-58). New York: Oxford University Press.

Hamre, B. K., & Pianta, R. C. (2005). Can instructional and emotional support in the first-grade classroom make a difference for children at risk of school failure? *Child Development, 76*(5), 949-967.

Himes, D., Pugach, M. C., & Staples, A. (2005). Rethinking the technology integration challenge: Cases from three urban elementary schools. *Journal of Research on Technology in Education, 37*(3), 285-311.

Hirumi, A. (2002). Student-centered, technology-rich learning environments (SCenTRLE): Operationalizing Constructivist Approaches to teaching and learning. *Journal of Technology and Teacher Education, 10*(4), 497-537.

Howery, B. B. (2001). Teacher technology training: A study of the impact of educational technology on teacher attitude and student achievement. *Dissertation Abstracts International, 62* (03), 861A. (UMI No. 3008753)

Jarrell, D. K. (2000). The effects of computer access on reading achievement. *Dissertation Abstracts International-A 61(05), 1807*A. (UMI No. 9973362)

Kadel, R (2005How teacher attitudes affect technology integration. *Learning and Leading with Technology, 32*(5), 34-35.

Karpyn, A. E. (2003). School technology use and achievement on statewide assessment: Is there a relationship? *Dissertation Abstracts International, 64* (06), 2052A. (UMI No. 3095897)

Kinzie, M. B., & Milbrath, Y. L. (2002). Technology training for prospective teachers. *Journal of Technology and Teacher Education, 8*(4), 373-396.

Laffey, J. M., Espinosa, L., Moore, J., & Lodree, A. (2003). Supporting learning and behavior of at-risk young children: Computers in urban education. *Journal of Research on Technology in Education, 35*(4), 423-435.

McCormack, A. (2002). Interactive computer-based technology in EFL. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2002* (pp. 1151-1152).

McNeil, L. M. (2000). *Contradictions of School Reform: Educational Costs of Standardized Testing.* New York: Routledge.

Means, B. (1994). *Technology and education reform: the reality behind the promise. San* Francisco: Jossey-Bass.

Mendels, P. (1999). Internet access spreads to more classrooms, survey finds. *Education.* Retrieved February 21, 2005, from http://www.tamucc.edu/-gblalock/courses/3360/readings/nytintacc.htm

The Metiri Group (2006, October 16). *Contemporary skills, contemporary learners.* Retrieved October 16, 2006, from http://www.metiri.com

Middleton, B. M., & Murray, R. K. (1999). The impact of instructional technology on student academic achievement in reading and mathematics. *International Journal of Instructional Media, 26*(1), 109-116.

Mintz, K. S. (2000). A comparison of computerized and traditional instruction in elementary mathematics. *Dissertation Abstracts International, 61* (03), 954A. (UMI No. 9966706)

Molnar, A. (1997). Computers in education: A brief history. *T.H.E. Journal, 24*(11), 63-68.

Moore, W. (2003). Facts and assumptions of assessment: Technology, the missing link. *T.H.E. Journal, 30*(6), 20-26.

Murray, C. (2004, November 23). Ed funds up $1.4B, ed-tech off $200M. *eSchool News Online.* Retrieved September 22, 2006, from http://www.eschoolnews.com/news/showStory.cfm?ArticleID=5388

Murray, C. (2005, December 22). Education takes $59M hit in new federal budget. *eSchool News Online.* Retrieved October 11, 2006, from http://www.eschoolnews.com/news/showStory.cfm?ArticleID=6010

The National Commission on Excellence in Education (1983). *A Nation at Risk: The Imperative for Educational Reform.* Washington, DC: Government Printing Office. Retrieved January 5, 2006, from http://www.ed.gov/pubs/NatAtRisk/index.html

Newburger, E. C. (2001, September). *Home Computers and Internet Use in the United States: August 2000.* U.S. Department of Economics: Economics and Statistics Administration. Retrieved September 8, 2006, from http://www.census.gov/prod/2001pubs/p23-207.pdf

Newcombe, N. S., & Terlecki, M. S. (2005). How important is the digital divide? The relation of computer and videogame usage to gender differences in mental rotation ability. *Sex Roles: A Journal of Research, 53*(5-6), 433-441.

No Child Left Behind Act of 2001, PL 107-110 U.S. Department of Education (2001). Retrieved April 7, 2005, from http://www.ed.gov/nclb/landing.html

Norris, C., Sullivan, T., Poirot, J., & Soloway, E. (2003). No access, no use, no impact: Snapshop surveys of education technology in K-12. *Journal of Research on Technology in Education, 36*(1), 15-23.

Ornstein, A. C., & Hunkins, F. P. (1998). *Curriculum: Foundations, principles, and issues* (3rd ed.). Needham Heights, MA: Allyn & Bacon.

Palmer, E. A. (2001). Cultural capital and school success: Implications for student achievement. *Dissertation Abstracts International, 62(01), 125A.* (UMI No. 9999978)

Perez, K. J. (1997). Predictors of achievement in mathematics and reading by elementary ESOL and non-ESOL students using a computer-based integrated learning system. *Dissertation Abstracts International, 59* (07), 2354A. (UMI No. 9838849)

Plowden, M. W. (2003). The relationship between technology and student achievement in selected inner schools of one public school system. *Dissertation Abstracts International, 64* (08), 2767A. (UMI No. 3102820)

Putnam, R. D. (2004). *Democracies in flux: The evolution of social capital in contemporary society.* New York: Oxford University Press.

Ritchie, K. G. (1999). An exploratory case study of the implementation of one computer assisted instruction program in reading. *Acquisitions and Bibliographic Services, National Library of Canada*. (ID No. 0-612-45116-X)

Rogoff, B. (2003). *The cultural nature of human development.* New York: Oxford University Press.

Rose, G. H. (1997). Gender and socioeconomic status as predictors of reading gain scores on the Stanford Achievement Test for fifth grade students who participated in computer assisted instruction. *Dissertation Abstracts International-A, 58* (10), 3875. (UMI No. 9811782)

Saiger, A. J. (2005). Legislating accountability: Standards, sanctions, and school district reform. *William and Mary Law Review, 46*(5), 1655-1733.

Schneiderman, M. (2004). What does SBR mean for education technology? *T.H.E. Journal, 31*(11), 30-34.

Scott, T., Cole, M., & Engel, M. (1992). Computers and education: A cultural constructivist perspective. *Review of Research in Education, 18*, 191-251.

Shields, M. K., & Behrman, R. E. (2000). Children and computer technology: Analysis and recommendations. *The Future of Children, 10*(2), 4-30.

Shuldman, M. (2004). Superintendent conceptions of institutional conditions that impact teacher technology integration. *Journal of Research on Technology in Education, 36*(4), 319-343.

Skinner, D. (1997, Summer). Computers: Good for education? *Public Interest,* 98-103.

Snider, S. L. (2002). Exploring technology integration in a field-based teacher education program: Implementation efforts and findings. *Journal of Research on Technology in Education, 34*(3), 230-247.

Tang-Lau, T. (2004). A descriptive study of AlphaSmarts in an elementary school district. *Dissertation Abstracts International, 65* (10), 3702A. (UMI No. 3008753)

Technology. (n.d.). *The American Heritage® Dictionary of the English Language, Fourth Edition*. Retrieved September 18, 2006, from Dictionary.com website: http://dictionary.reference.com/search?q=technology&x=48&y=18

Tracey, D. H., & Young, J. W. (2006). *Technology and early literacy: The impact of an integrated learning system on high risk kindergartners' achievement.* Unpublished manuscript. (ERIC Document Reproduction Service No. ED491554.

U.S. Department of Education, Institute of Education Sciences. (n.d.). *What Works Clearinghouse.* U.S. Department of Education. Available from What Works Clearinghouse Web site, http://www.whatworks.ed.gov

U.S. Department of Education (2002a). *Educational technology research and evaluation.* Retrieved January 26, 2006, from http://www.visions2020.gov/FedEfforts/DeptEduc-0403.pdf

U.S. Department of Education (2002b). *Enhancing Education Through Technology Act of 2001*. Retrieved July 5, 2006, from http://www.ed.gov/policy/elsec/leg/esea02/pg34.html#sec2401

U.S. Department of Education (2004). Toward a new golden age in American education: How the Internet, the law, and today's students are revolutionizing expectations. U.S. Department of Education (Author). Retrieved July 15, 2006, from http://www.NaationalEdTechPlan.org

Verillon, P. (2000). Revisiting Piaget and Vigotsky: In search of a learning model for technology education. *Journal of Technology Studies,* 26(1). Retrieved June 22, 2006, from scholar.lib.vt.edu/ejournals/JTS/Winter-Spring-2000/pdf/verillon.pdf

Washington, S. T. (2003). Teachers' perceptions of the implementation of the Waterford Early Reading Program, a computer-based instruction program: A case study of the evidence from teachers' interviews and students' achievement data in selective Pennsylvania urban elementary schools. *Dissertation Abstracts International, 64* (07), 2341A. (UMI No. 3099994)

What Works Clearinghouse (2002). *What we do: Overview.* U.S. Department of Education: Institute of Education Sciences. Retrieved September 17, 2006, from http://www.whatworks.ed.gov/whatwedo/overview.html

Wiggins, G., & McTighe, J. (2005). *Understanding by design.* Alexandria, VA: Association for Supervision and Curriculum Development.

U. S. Department of Education (n.d.). *Number and characteristics of students with disabilities in inner-city districts: To assure the free appropriate public education of all children with disabilities – 1996.*. Retrieved October 27, 2006, from http://www.ed.gov/pubs/OSEP96AnlRpt/chap4a.html#foot3

APPENDIX A

Tukey HSD Comparison of Student Demographics between Participating Schools

Multiple Comparisons

Dependent Variable: DiffPrePostRdg
Tukey HSD

(I) Grade 3 PSSA Rdg	(J) Grade 3 PSSA Rdg	Mean Difference (I-J)	Std. Error	P	95% Confidence Interval Upper Bound	95% Confidence Interval Lower Bound
Below Basic	Basic	6.2392	37.39730	.998	-90.4798	102.9582
	Proficient	40.5478	32.79854	.604	-44.2776	125.3732
	Advanced	111.4266(*)	34.89388	.009	21.1821	201.6710
Basic	Below Basic	-6.2392	37.39730	.998	-102.9582	90.4798
	Proficient	34.3086	24.39242	.496	-28.7764	97.3936
	Advanced	105.1874(*)	27.14458	.001	34.9845	175.3902
Proficient	Below Basic	-40.5478	32.79854	.604	-125.3732	44.2776
	Basic	-34.3086	24.39242	.496	-97.3936	28.7764
	Advanced	70.8788(*)	20.34735	.003	18.2553	123.5022
Advanced	Below Basic	-111.4266(*)	34.89388	.009	-201.6710	-21.1821
	Basic	-105.1874(*)	27.14458	.001	-175.3902	-34.9845
	Proficient	-70.8788(*)	20.34735	.003	-123.5022	-18.2553

Based on observed means.
* The mean difference is significant at the .05 level.

APPENDIX B

Multivariate Tests(c): Reading and Reading* by CompassLearning Subject

Effect		Value	F	Hypothesis df	Error df	P	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Reading	Pillai's Trace	.005	1.294(b)	1<.001	277<.001	.256	.005	1.294	.205
	Wilks' Lambda	.995	1.294(b)	1<.001	277<.001	.256	.005	1.294	.205
	Hotelling's Trace	.005	1.294(b)	1<.001	277<.001	.256	.005	1.294	.205
Reading * CLsubject									
	Pillai's Trace	.086	13.014(b)	2<.001	277<.001	<.001	.086	26.027	.997
	Wilks' Lambda	.914	13.014(b)	2<.001	277<.001	<.001	.086	26.027	.997
	Hotelling's Trace	.094	13.014(b)	2<.001	277<.001	<.001	.086	26.027	.997

a Computed using alpha = .05
b Exact statistic
c Design: Intercept+CLsubject
Within Subjects Design: Reading

APPENDIX C

F Tests for Reading Multivariate Tests: Tests of Within-Subject Effects between Access Type and Achievement

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	P	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Reading	Sphericity Assumed	12801.276	1	12801.276	1.294	.256	.005	1.294	.205
	Greenhouse-Geisser	12801.276	1<.001	12801.276	1.294	.256	.005	1.294	.205
	Huynh-Feldt	12801.276	1<.001	12801.276	1.294	.256	.005	1.294	.205
	Lower-bound	12801.276	1<.001	12801.276	1.294	.256	.005	1.294	.205
Reading * CLsubject	Sphericity Assumed	257503.659	2	128751.830	13.014	<.001	.086	26.027	.997
	Greenhouse-Geisser	257503.659	2<.001	128751.830	13.014	<.001	.086	26.027	.997
	Huynh-Feldt	257503.659	2<.001	128751.830	13.014	<.001	.086	26.027	.997
	Lower-bound	257503.659	2<.001	128751.830	13.014	<.001	.086	26.027	.997
Error(Reading)	Sphericity Assumed	2740533.053	277	9893.621					
	Greenhouse-Geisser	2740533.053	277<.001	9893.621					
	Huynh-Feldt	2740533.053	277<.001	9893.621					
	Lower-bound	2740533.053	277<.001	9893.621					

a Computed using alpha = .05

APPENDIX D

Tests of Between-Subjects Effects: The Effect of CompassLearning Use on Reading

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	P	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	956510803.765	1	956510803.765	18672.208	<.001	.985	18672.208	1<.001
CLsubject	7326.986	2	3663.493	.072	.931	.001	.143	.061
Error	14189724.998	277	51226.444					

a Computed using alpha = .05

APPENDIX E

Wilks' Lambda: Correlation between Minutes per Month and Minutes per Activity and Achievement

Multivariate Tests(c)

Effect		Value	F	Hypothesis df	Error df	P	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Reading	Pillai's Trace	.017	4.652(b)	1<.001	267<.001	.032	.017	4.652	.575
	Wilks' Lambda	.983	4.652(b)	1<.001	267<.001	.032	.017	4.652	.575
	Hotelling's Trace	.017	4.652(b)	1<.001	267<.001	.032	.017	4.652	.575
	Roy's Largest Root	.017	4.652(b)	1<.001	267<.001	.032	.017	4.652	.575
Reading * CL Min/Month	Pillai's Trace	.007	.965(b)	2<.001	267<.001	.382	.007	1.931	.217
	Wilks' Lambda	.993	.965(b)	2<.001	267<.001	.382	.007	1.931	.217
	Hotelling's Trace	.007	.965(b)	2<.001	267<.001	.382	.007	1.931	.217
	Roy's Largest Root	.007	.965(b)	2<.001	267<.001	.382	.007	1.931	.217
Reading * CL Min/Activity	Pillai's Trace	.045	3.135(b)	4<.001	267<.001	.015	.045	12.539	.814
	Wilks' Lambda	.955	3.135(b)	4<.001	267<.001	.015	.045	12.539	.814
	Hotelling's Trace	.047	3.135(b)	4<.001	267<.001	.015	.045	12.539	.814
	Roy's Largest Root	.047	3.135(b)	4<.001	267<.001	.015	.045	12.539	.814
Reading * CL Min/Month * CL Min/Activity	Pillai's Trace	.030	1.388(b)	6<.001	267<.001	.219	.030	8.331	.539
	Wilks' Lambda	.970	1.388(b)	6<.001	267<.001	.219	.030	8.331	.539
	Hotelling's Trace	.031	1.388(b)	6<.001	267<.001	.219	.030	8.331	.539
	Roy's Largest Root	.031	1.388(b)	6<.001	267<.001	.219	.030	8.331	.539

a Computed using alpha = .05
b Exact statistic
c Design: Intercept+CL Min/Month+CL Min/Activity+CL Min/Month * CL Min/Activity
Within Subjects Design: Reading

APPENDIX F

F Tests for Reading Multivariate Tests: Tests of Within-Subject Effects between Level of Use and Achievement

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	P	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Reading	Sphericity Assumed	47638.024	1	47638.024	4.652	.032	.017	4.652	.575
	Greenhouse-Geisser	47638.024	1<.001	47638.024	4.652	.032	.017	4.652	.575
	Huynh-Feldt	47638.024	1<.001	47638.024	4.652	.032	.017	4.652	.575
	Lower-bound	47638.024	1<.001	47638.024	4.652	.032	.017	4.652	.575
Reading * CL Min/Month	Sphericity Assumed	19774.963	2	9887.481	.965	.382	.007	1.931	.217
	Greenhouse-Geisser	19774.963	2<.001	9887.481	.965	.382	.007	1.931	.217
	Huynh-Feldt	19774.963	2<.001	9887.481	.965	.382	.007	1.931	.217
	Lower-bound	19774.963	2<.001	9887.481	.965	.382	.007	1.931	.217
Reading * CL Min/Activity	Sphericity Assumed	128407.976	4	32101.994	3.135	.015	.045	12.539	.814
	Greenhouse-Geisser	128407.976	4<.001	32101.994	3.135	.015	.045	12.539	.814
	Huynh-Feldt	128407.976	4<.001	32101.994	3.135	.015	.045	12.539	.814
	Lower-bound	128407.976	4<.001	32101.994	3.135	.015	.045	12.539	.814
Reading * CL Min/Month * CL Min/Activity	Sphericity Assumed	85315.468	6	14219.245	1.388	.219	.030	8.331	.539
	Greenhouse-Geisser	85315.468	6<.001	14219.245	1.388	.219	.030	8.331	.539
	Huynh-Feldt	85315.468	6<.001	14219.245	1.388	.219	.030	8.331	.539
	Lower-bound	85315.468	6<.001	14219.245	1.388	.219	.030	8.331	.539
Error(Reading)	Sphericity Assumed	2734320.528	267	10240.901					
	Greenhouse-Geisser	2734320.528	267<.001	10240.901					
	Huynh-Feldt	2734320.528	267<.001	10240.901					
	Lower-bound	2734320.528	267<.001	10240.901					

Measure: MEASURE_1
a Computed using alpha = .05

APPENDIX G

Tests of Between-Subjects Effects: The Effect of Gender, SES, Prior Achievement and IEP on Reading Achievement

Tests of Between-Subjects Effects

Dependent Variable: DiffPrePostRdg

Source	Type III Sum of Squares	df	Mean Square	F	P	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	923377.005(b)	8	115422.126	6.166	<.001	.154	49.330	1<.001
Intercept	575203.822	1	575203.822	30.729	<.001	.102	30.729	1<.001
Gr3RdgScaled	613265.079	1	613265.079	32.763	<.001	.108	32.763	1<.001
Gender	13399.297	1	13399.297	.716	.398	.003	.716	.135
SES	48786.905	1	48786.905	2.606	.108	.010	2.606	.363
IEP	201719.858	1	201719.858	10.777	.001	.038	10.777	.905
Gender * SES	6066.678	1	6066.678	.324	.570	.001	.324	.088
Gender * IEP	17091.530	1	17091.530	.913	.340	.003	.913	.159
SES * IEP	42394.021	1	42394.021	2.265	.134	.008	2.265	.323
Gender * SES * IEP	4315.924	1	4315.924	.231	.631	.001	.231	.077
Error	5072696.420	271	18718.437					
Total	5996075<.001	280						
Corrected Total	5996073.425	279						

a Computed using alpha = .05

b R Squared = .154 (Adjusted R Squared = .129)

APPENDIX H

Multivariate Tests(c): The Effect of CompassOdyssey Mathematics on Achievement

Multivariate Tests(c)

Effect		Value	F	Hypothesis df	Error df	P	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Math	Pillai's Trace	.028	7.654(b)	1<.001	267<.001	.006	.028	7.654	.787
	Wilks' Lambda	.972	7.654(b)	1<.001	267<.001	.006	.028	7.654	.787
	Hotelling's Trace	.029	7.654(b)	1<.001	267<.001	.006	.028	7.654	.787
Math * CL Min/Month	Pillai's Trace	.007	.914(b)	2<.001	267<.001	.402	.007	1.827	.207
	Wilks' Lambda	.993	.914(b)	2<.001	267<.001	.402	.007	1.827	.207
	Hotelling's Trace	.007	.914(b)	2<.001	267<.001	.402	.007	1.827	.207
Math * CL Min/Activity	Pillai's Trace	.056	3.960(b)	4<.001	267<.001	.004	.056	15.840	.903
	Wilks' Lambda	.944	3.960(b)	4<.001	267<.001	.004	.056	15.840	.903
	Hotelling's Trace	.059	3.960(b)	4<.001	267<.001	.004	.056	15.840	.903
Math * CL Min/Month * CL Min/Activity	Pillai's Trace	.011	.503(b)	6<.001	267<.001	.806	.011	3.016	.202
	Wilks' Lambda	.989	.503(b)	6<.001	267<.001	.806	.011	3.016	.202
	Hotelling's Trace	.011	.503(b)	6<.001	267<.001	.806	.011	3.016	.202

a Computed using alpha = .05
b Exact statistic
c Design: Intercept+CL Min/Month+CL Min/Activity+CL Min/Month * CL Min/Activity
Within Subjects Design: Math

APPENDIX I

Wilks' Lambda: Correlation between Minutes per Month and Minutes per Activity with CompassLearning Software and Reading Achievement

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	P	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Intercept	175143155.026	1	175143155.026	2772.801	<.001	.912	2772.801	1<.001
CL Min/Month	421165.623	2	210582.812	3.334	.037	.024	6.668	.628
CL Min/Activity	622327.698	4	155581.924	2.463	.046	.036	9.852	.700
CL Min/Month * CL Min/Activity	192779.724	6	32129.954	.509	.802	.011	3.052	.205
Error	16864974.239	267	63164.698					

a Computed using alpha = .05

APPENDIX J

Correlation between Usage Groups, Time on Task in Mathematics, and Achievement

Multivariate Tests(b)

Effect		Value	F	Hypothesis df	Error df	P
math	Pillai's Trace	.283	109.541(a)	1<.001	277<.001	<.001
	Wilks' Lambda	.717	109.541(a)	1<.001	277<.001	<.001
	Hotelling's Trace	.395	109.541(a)	1<.001	277<.001	<.001
	Roy's Largest Root	.395	109.541(a)	1<.001	277<.001	<.001
math * CLsubject	Pillai's Trace	.171	28.510(a)	2<.001	277<.001	<.001
	Wilks' Lambda	.829	28.510(a)	2<.001	277<.001	<.001
	Hotelling's Trace	.206	28.510(a)	2<.001	277<.001	<.001
	Roy's Largest Root	.206	28.510(a)	2<.001	277<.001	<.001

a Exact statistic
b Design: Intercept+CLsubject
 Within Subjects Design: math

APPENDIX K

Tests of Between-Subjects Effects: The Effect of Gender, SES, Prior Achievement and IEP on Mathematics Achievement

Tests of Between-Subjects Effects

Dependent Variable: DiffPrePostMath

Source	Type III Sum of Squares	df	Mean Square	F	P	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	347129.024(b)	8	43391.128	1.350	.219	.038	10.800	.613
Intercept	138067.784	1	138067.784	4.296	.039	.016	4.296	.542
Gr3RdgScaled	23912.404	1	23912.404	.744	.389	.003	.744	.138
Gender	98078.731	1	98078.731	3.052	.082	.011	3.052	.413
SES	128975.171	1	128975.171	4.013	.046	.015	4.013	.514
IEP	32120.558	1	32120.558	.999	.318	.004	.999	.169
Gender * SES	100984.779	1	100984.779	3.142	.077	.011	3.142	.423
Gender * IEP	53592.430	1	53592.430	1.667	.198	.006	1.667	.251
SES * IEP	53576.557	1	53576.557	1.667	.198	.006	1.667	.251
Gender * SES * IEP	88954.901	1	88954.901	2.768	.097	.010	2.768	.381
Error	8710099.419	271	32140.588					
Total	13277128<.001	280						
Corrected Total	9057228.443	279						

a Computed using alpha = .05
b R Squared = .038 (Adjusted R Squared = .010)

Appendix L

One-way Anova Descriptive Comparison of Means between Groups of Mathematics

Software Users

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Compass Minutes per Month	Teacher D	23	1.9130	.79275	.16530	1.5702	2.2559	1.00	5.00
	Teacher G	20	2.4000	1.14248	.25547	1.8653	2.9347	1.00	5.00
	Teacher I	16	2.0000	.00000	.00000	2.0000	2.0000	2.00	2.00
	Teacher J	16	4.0625	1.43614	.35904	3.2972	4.8278	2.00	5.00
	Teacher K	15	4.4000	1.24212	.32071	3.7121	5.0879	2.00	5.00
	Teacher L	18	1.1111	.32338	.07622	.9503	1.2719	1.00	2.00
	Teacher N	17	1.5882	1.00367	.24343	1.0722	2.1043	1.00	5.00
	Total	125	2.4160	1.45460	.13010	2.1585	2.6735	1.00	5.00
Compass Minutes per Session	Teacher D	23	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	Teacher G	20	1.6500	.58714	.13129	1.3752	1.9248	1.00	3.00
	Teacher I	16	1.1250	.34157	.08539	.9430	1.3070	1.00	2.00
	Teacher J	16	1.1875	.40311	.10078	.9727	1.4023	1.00	2.00
	Teacher K	15	1.0667	.25820	.06667	.9237	1.2097	1.00	2.00
	Teacher L	18	1.0556	.23570	.05556	.9383	1.1728	1.00	2.00
	Teacher N	17	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
	Total	125	1.1600	.38938	.03483	1.0911	1.2289	1.00	3.00