TECHNOLOGY FOR AFTERSCHOOL PROGRAMS

A Review of Literature and Research Studies

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Technology for Afterschool Programs

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SECTION I
INTRODUCTION

The Potential for Educational Technology

Computers and access to the Internet provide tremendous opportunities for students in afterschool programs to reinforce reading, math, and writing skills as well as complete homework and school assignments. Information-gathering, report-writing, art, math, and problem-solving projects often necessitate using tools that only computer technology can provide. In addition, electronic technology can be used to connect families and students with community resources such as museums, libraries, and other community centers. In a survey of afterschool programs by the U.S. Department of Education (1999), parents cited access to technology and computer literacy as their number one priority for afterschool activities.

The No Child Left Behind Education Act of 2001 (NCLB) requires that every student be technology literate by the time they finish the eighth grade. To support this requirement, the Enhancing Education Through Technology (EETT) initiative (2001), a component of NCLB, has provided approximately $500–700 million annually to schools across the nation. Schools have made great strides in acquiring technology infrastructure and training to support technology integration into schools and their curricula. While the initial focus was on acquisition and installation of technology hardware and its components, the focus has now shifted to using technology as a tool to improve academic achievement.

The 21st Century Community Learning Centers program (21st CCLC), also a key component of No Child Left Behind, provides an opportunity for students and their families to continue learning after the regular school day has ended. The foci of this program are expanded academic enrichment opportunities for children attending low-performing schools and youth development in technology, the arts, and the academic content areas of literacy, science, and math. By tapping into those technology resources that have been put in place by the EETT grants, the 21st CCLC programs have an opportunity to create technology-rich activities and programs to attract and maintain high student interest while improving academic achievement.

Technology for Afterschool

Successful afterschool programs provide an opportunity to integrate "rich content into fun, experiential learning fueled by the imagination and enthusiasm of the young participants" (Chun, 2005). YouthLearn, a non profit organization dedicated to the development of youth, learning, and technology created by the Morino Institute and now led by Education Development Center, Inc., approaches technology both as a set of skills to be mastered and as a powerful tool to be used in everyday activities such as homework, communicating with friends, and researching interests.

In a statistical analysis report for the National Center for Education Sciences (NCES), DeBell and Chapman (2003) examined the use of computers and the Internet by American children and adolescents between the ages of 5 and 17. This report is based on data collected in the September Computer and Internet Use supplement of the 2001 Current Population Survey. DeBell and Chapman found that about 90% of children and adolescents in that age group use computers, with about 59% using the Internet. While the adoption of these technologies has been rapid, the use of computers and the Internet varies by socioeconomic status as well as race/ethnicity and education level. DeBell and Chapman concluded that a digital divide exists.

The report results show that use of computers is higher among Whites than among Blacks and Hispanics. Those children in the study who live with more highly educated parents are also more likely to use computers and the Internet than those living in households with parents with lower education levels. Those living in households with higher family incomes are more likely to use computers and the Internet than those living in lower income households. The report also revealed that about 80% of adult college graduates use the Internet; 42% of high school graduates use the Internet; and 17% of non-high school graduates use the Internet.

The report indicates that schools appear to have a role in helping narrow the digital divide in terms of computer use. Disadvantaged children and adolescents use the Internet at a higher rate at school than non-disadvantaged students. The report showed that 52% of students who use computers at school are from families with an annual income below $35,000, and 59% of those students have parents who have not completed high school. These figures point to a need and opportunity for afterschool programs.

Student Technology Standards

To live, learn, and work successfully in an increasingly complex and information-rich society, today's students must be able to use technology effectively. Technology has become a powerful catalyst in promoting learning, communications, and life skills for economic survival in today's world. To encourage educational leaders to provide learning opportunities that can produce technology-capable students, the International Society for Technology in Education (ISTE) introduced the National Educational Technology Standards (NETS) for students (Appendix II). These national standards are designed to provide U.S. educators with frameworks and standards to guide them in establishing enriched learning environments supported by technology. The NETS for students were released in June 1998, and since that time, 38 states have either adopted or reference the ISTE student technology standards in their state technology plans, curriculum plans, or assessment plans.

The Partnership for 21st Century Skills, the leading advocacy organization for technology in education, has created a framework for defining and infusing technological literacy and skills into math, science, literacy, and geography content areas. These 21st Century life skills, which redefine the earlier definition created by the U.S. Department of Labor and the Education Secretary's Commission on Achieving Necessary Skills (SCANS 2000), (U.S. Department of Labor, June 1991), support the ISTE technology standards and further complement the efforts of the 21st CCLC program. The goals of these organizations generally seek to create students who are

- capable information technology users;
- information seekers, analyzers, and evaluators;
- problem solvers and decision makers;
- creative and effective users of productivity tools;
- communicators, collaborators, publishers, and producers; and
- informed, socially responsible, self-directed, and contributing citizens.

The Promise of Technology

With vital concerns regarding bringing about positive achievement gains, educators look to computer technologies as a way to reach their academic goals. They have listened as forward thinkers and technology leaders have promoted and promised the potential of computer technologies for revolutionizing teaching and learning. For example, in their chapter of the book *How People Learn: Brain, Mind, Experience, and School,* Bransford, Brown, and Cocking (1999) describe how tools and strategies, with the use of technology, can enhance students' increased access to knowledge and learning. *How People Learn* was the product of a 2-year project during which several experts in the field of cognitive science worked together to evaluate new developments in the science of learning. They wanted to broaden the understanding of how cognitive science has influenced science and math learning and teaching. As a result of this work, computer-based technologies were considered to be potentially powerful pedagogical tools for teaching and learning.

The CEO Forum on Education and Technology, a unique partnership between business and education leaders committed to assessing and monitoring the progress toward integrating technology into America's schools, offers recommendations to federal policymakers regarding expanding educational technology investments as a way to boost student achievement. The CEO Forum has developed self-assessment tools, called StaR charts, for schools and teachers to gauge their progress toward integrating technology to improve education and has participated in the creation of objectives for developing 21st century skills.

The Partnership for 21st Century Skills is another leading national advocacy organization focused on transforming teaching and learning in the 21st century. Many of its members are also members of the CEO Forum. The purpose of this organization is to define a powerful vision for 21st century education to ensure every child's success as citizens and workers in the 21st century and to promote technology in education as a way to create "capable information technology users." The partnership is currently developing literacy maps that show how information and communication technologies can be incorporated into academic content areas. This organization holds the belief that successful businesses are looking for employees who can adapt to changing needs, juggle multiple responsibilities, and routinely make decisions on their own. Its mission is to infuse 21st century skills into K–12 education in order to ensure every child's success as citizens and workers in the 21st century. The Partnership for 21st Century Skills was formed in 2002 and is composed of the following entities: U.S. Department of Education, AOL Time Warner Foundation, Apple Computer, Inc., Cable in the Classroom, Cisco Systems, Inc., Dell Computer Corporation, Microsoft Corporation, National Education Association, SAP, American Association of School Libraries, Consortium for School Networking, International Society for Technology in Education, National 4-H Council, State Educational Technology Directors Association, and TECH CORPS.

With increased pressure from national, state, and local policy groups to invest in hardware, software, networks, and teacher training, there is also increased pressure for accountability measures for these investments. Many educators have become disillusioned as unrealistic and unsubstantiated claims about the benefits of technology use in education have not been realized. As a result, there is an increased demand for quality research documenting the impact and contribution of computer technology on educational outcomes.

SECTION II
ABOUT THIS PAPER

Purpose

The purpose of this paper is to provide a synthesis of relevant research studies regarding the use of technology in K–12 academic settings and to show how those results inform our decisions regarding technology use in afterschool settings.

Selection Process

Because there are already several reputable meta-analyses available, conducting yet another meta-analysis of research studies regarding technology and K–12 education uses was determined to be beyond the scope of this paper. Therefore, the decision was made to find and focus on meta-analyses and major studies carried out by recognized researchers or work sponsored by recognized research and educational institutions.

As experienced professionals in the field of educational technology, the reviewers drew on their professional knowledge when conducting and selecting relevant studies for review. One of the reviewers had participated in two other syntheses regarding K–12 technology (Heath & Holznagel, 2002; Boethel & Dimock, 1999) and retrieved some of those studies in both print and electronic formats. Searches were also conducted primarily through electronic means for major reports that synthesized quantitative, experimental, quasi-experimental, or evaluation results of technology use and integration in K–12 academic settings. Please note that the reviewers will continue to look for newer studies as they are published or discovered and reviews of these studies will be added to this paper where appropriate.

Hundreds of studies, articles, and books about computers in educational settings have been written over the past 2 decades. Some early studies were considered too out-of-date for this review. The reviewers attempted to find studies or reports from the late 1990s through 2005. The material was first sorted into different categories based on topic and focus: comparison studies or intervention studies using specific software in a classroom; reviews of specific software titles; case studies of classrooms and schools; lessons learned; trends and future opportunities; computers and cognition; reviews of research studies; national policy papers; ways to teach with technology; and in-depth research and meta-analysis studies. From this last category, the reviewers determined that 10–15 papers offered studies that fit the requirements of evidence-based research. Other related articles from leaders in the field were also cited in this synthesis when appropriate to support a point.

The reviewers found few published studies specific to technology in afterschool settings. However, the reviewers regard studies about technology and its educational impact on student learning in in-school settings also can be useful for understanding the impact in afterschool programs because many of the same issues arise (i.e., How can technology can help increase learning in academic content areas? What are the best instructional practices? How can technology increase students' cognitive skills? How do we address practical technology management issues, effective curriculum design, and professional development for teachers?).

This document will provide a description of the different types and uses of educational technology and then describe related research studies that support their use. At the end of the paper, the strengths and weaknesses of the different types of technology will be summarized to provide the reader with information for making informed choices regarding various educational technologies.

SECTION III
UNDERSTANDING PEDAGOGICAL USES OF TECHNOLOGY

Over the past few years, technology's capabilities have expanded and now provide a wide variety of tools for carrying out relevant, interactive, and creative projects and problem-solving activities across all academic content areas. These capabilities can enhance student achievement and spark student engagement. While most educators and policy makers suggest that all students have access to and be able to use technology in today's environment, not all agree on how it is best used for instructional purposes. Afterschool decision makers should develop an understanding of different types of software applications and their corresponding instructional purposes so they can make informed decisions regarding the purchase and appropriate use of these applications in their programs. The following section will provide a description of the different educational technology types, their use, and related research studies. The model that Maddux, Johnson, and Willis (1997) developed to describe the different types of educational software applications, called Type I and Type II (see Appendix III), is used for this discussion. This model of comparison emphasizes pedagogical uses as well as instructional *benefits* of various applications rather than specific *features* of a technology application.

Type I Applications

Type I technology applications are often used to diagnose and teach skills in various content areas. Instruction is organized around specific objectives and often embodies a mastery approach to instruction. There are thousands of commercial educational technology programs available today that could be considered Type I. They teach a broad range of subjects from reading readiness to college-level engineering physics. Typically a learning theory or teaching strategy serves as the framework for Type I programs. These programs can cost a few dollars for simple ones or several thousand dollars for more complex applications or complete academic curricula. Educational software applications used primarily for this type of learning are sometimes called CBI (computer-based instruction), CAI (computer-assisted instruction), ILS (integrated learning systems), ITS (intelligent learning systems), or simply tutorial software. Some familiar commercial examples of these programs are Cognitive Tutor (Algebra), PLATO, Waterford Early Reading Program, Success Maker, and Odyssey.

With Type I software applications, the software designers and developers of the software control the interactions between user and machine and predetermine almost everything that happens on the screen. Students can learn "from" the computer, which generally functions as a tutor (Reeves, 1998). Sometimes these applications are described as "full" because users cannot add anything to the application itself other than his or her responses (Jonassen & Stollenwerk, 1999).

When computers were first introduced to the classroom several years ago, most commercial applications fell within the Type I category of development and use and were fairly limited in their scope and purpose. With the improvement of the technology itself, however, Type I applications have improved in their user-friendliness and usefulness by supporting the use of color, graphics, multimedia applications, and student-computer interactions as well as the inclusion of analysis and assessment tools. Applications of this type should be chosen based on their support of academic and instructional goals. When they are used as add-on activities that don't complement curricular efforts, they have no positive effect on student achievement (Wenglinsky, 1998). In addition, integrated learning systems require a significant commitment of implementation expense, time, and effort. Systems of this type commonly require contractual agreements from the publisher or developer and specific implementation guidelines. As a whole, integrated learning systems and other Type I applications should be chosen based on how they support instructional goals and the curriculum as a whole.

Type II Applications

Type II applications are usually aimed at personal productivity, creating products and projects, communication, investigation, and discovery. The user, rather than the software developer, is in charge of the interaction with the content. The student experiences learning "with" the computer rather than learning "from" the computer (Reeves, 1998). Type II applications include word-processing programs, presentation programs, spreadsheet programs, multimedia, the Internet, e-mail, concept mapping, simulations, scientific instruments and music making. It can take many hours of use before the user masters everything that a specific Type II program is capable of doing. Sometimes described as "empty" (Jonassen & Stollenwerk, 1999), learning with this type of technology offers students the opportunity to develop higher levels of critical thinking, creativity, and problem-solving skills.

Like Type I applications, Type II applications should be chosen based on how they support instructional goals. Learning how to use the software application and learning how to integrate the software application into academic activities are two major issues that must be addressed when selecting Type II applications for instructional purposes.

Type I Research Studies

SRI International's Center for Technology in Learning conducted a meta-analysis on the effectiveness of technology that looked specifically at Type I, or "discrete," educational software applications such as integrated learning systems, computer-assisted instruction, computer-based instruction, and tutorial software designed to teach reading and mathematics (Murphy, R., Penuel, W., Means, B., Korbak, C. & Whaley, A., 2001). Out of the 195 studies found, only 31 met the requirements for analysis: the use of a comparison group, large enough samples, reliable measures of achievement, and sufficient information for estimating an effect size. The authors of the study reported that there is a limited research base in this area of technology effectiveness and many studies failed to report the basic information needed to evaluate their outcomes. From the studies they did evaluate, they "found evidence of a positive association between student achievement and the use of discrete educational software products to support instruction in reading and math" (p. 38).

Kulik conducted a meta-analysis in 1994 and then another in 2003 that focused on the impact of (Type I) computer-based applications such as tutorial, drill and practice, and integrated learning systems on content areas of reading, writing, and math. In the 2003 report he used two different review methods for the literature covered: (a) a review of actual studies published since 1990, and (b) literary reviews for those studies made during the 1970s and 1980s.

Kulik's 2003 meta-analysis reports findings from controlled evaluations of instructional technology and reading in elementary and secondary schools. It computes the effect sizes drawn from 27 studies that focused on three (Type I) technology applications: 1) integrated learning systems (ILSs), 2) writing-based reading programs, and 3) reading management programs.

An integrated learning system (ILS) is a software program that provides sequential instruction for students while keeping records of their progress. Most ILS programs use tutorial instruction as a basic teaching methodology. Nine controlled studies during the last decade suggest that learning to read from integrated learning systems does not make meaningful contributions to reading improvement. However, Kulik makes two points: 1) students do improve as much with ILS instruction as they do with traditional reading instruction; and 2) it is possible students would do better with ILS if schools would allot more time to ILS instruction as the studies indicated students only spend a fraction of the time recommended for ILS instruction.

Writing to Read (WTR) is a computer program that reportedly teaches children to read through their writing. Kulik notes that evaluations of this program from the 1970s and 1980s differ greatly from those made since 1990. He examined the effect sizes of 12 evaluation studies made in the last decade and found strong positive effects in kindergarten, medium-size effects in first grade, and small effects beyond first grade.

Reading management programs, such as Accelerated Reader (AR), help students select books to read and then quiz them on what they have read. The AR program has been in wide use for several years, and during the past decade evaluators have carried out both statewide correlation studies and controlled studies of AR. Three statewide correlation studies showed that reading scores were higher at schools that owned AR. Other factors, however, may have contributed to the correlation between AR ownership and school achievement. Results of three controlled comparisons with math and science studies from schools that owned AR showed mixed results. Consequently, the Kulik meta-analysis suggests that too few controlled studies of AR are available for firm conclusions regarding its overall effectiveness.

Kulik reviewed 12 controlled evaluation studies that examined the effects of the aid of technology on student writing. Technology software types fell into the following categories: word processing, computer writing prompts, and computer enrichment. Word processing studies evaluated students who wrote using word processing software on a computer to students who wrote using paper and pencil. Word processing effects were positive although small. Generally speaking, however, studies showed that students learned to write better if they used word processors to write their papers. Computer writing prompts (clues or hints) have been added to some word processing programs to help improve student writing. Research is limited regarding the use of prompts, but what has been done shows that when students receive unsolicited prompts as they write, prompting is effective. However, if the program requires that students request a prompt, prompting is ineffective. More research needs to be done to support this conclusion.

The computer enrichment programs that were included in the evaluation studies that Kulik examined included simulations, research programs, games, and others. A common goal of these enrichment programs was to help students develop writing skills through authentic writing tasks. Kulik commented that during the 1970s and 1980s, evaluation studies seldom examined the effects of writing programs that included computer enrichment. Of the 96 evaluation studies described in Kulik's 1994 review of the literature on instructional technology in elementary and secondary schools, only five examined effects of computer enrichment on writing. Six studies published since 1990 paint a more positive picture. Four of the evaluation studies found positive effects on student learning, and the other two studies found negative effects.

In mathematics and science content areas, Kulik reviewed 36 controlled evaluation studies on the effects of technology on math and science learning. Technologies reviewed were Type I applications and included integrated learning systems, computer tutorials, computer simulations, and microcomputer-based laboratories.

Integrated learning systems (ILSs) were evaluated in 16 controlled evaluation studies from the last decade. The result from each group's math test scores increased at least slightly, and in nine cases, the test scores increase was large enough to be considered both statistically significant and educationally meaningful. In seven of the studies, students received ILS instruction only in math, but in the other nine, students received ILS in math and reading. The positive effects of the ILS were higher in the groups that received ILS only in math.

Kulik reports that six studies conducted during the past decade show positive results of computer tutorials in the natural and social sciences. In all but one of the six cases, the effect of computer tutoring was large enough to be considered both statistically significant and educationally meaningful. Evaluation studies carried out during the 1970s and 1980s also found that computer tutoring has positive effects on student learning in math.

Computer tutorials resulted in a positive effect on attitudes toward instruction and content matter. Controlled evaluation studies of computer tutorials in math and reading also showed positive effects on student learning. However, not enough studies include science to make a conclusion regarding that content area.

Computer simulations provide science students with theoretical or simplified models of real-world phenomena and situations. Science teachers liked to use simulations because they authenticate learning and require students to use high-level thinking. Six controlled evaluation studies conducted before 1990 had as many negative results as positive; however, controlled studies since then have had more positive results, with four of six studies finding positive effects on student learning.

Microcomputer-based laboratories (MBLs) use electronic sensors to collect data on physical systems, convert analog data into digital input, and transform digital data to a graphical system; consequently, students witnessed a phenomenon in the lab while concurrently viewing the development of a graph describing the phenomenon. Reviewers had a hard time finding controlled studies that showed learning advantages for MBL; in fact, only eight controlled studies were available for study, and one had a design flaw. Students who learned in MBLs typically performed no better on tests than did students who learned in conventional labs.

Kulik's earlier meta-analysis report (1994) indicated that students who used computer-based instruction scored higher on achievement tests (64% average versus 50% average) and learned more in less time. However, Kulik's later report (2003) provides mixed results for using computer-based applications. While the 2003 report seems uneven regarding the contribution of computer-based programs to instructional improvement, results are consistent enough for Kulik to make tentative conclusions:

1) ILSs make little or no contribution to reading improvement (however, studies show that ILSs are usually incompletely implemented);
2) computer word processing programs can be valuable tools in improving writing skills;

3) computer tutorials have consistently shown educational benefits; and
4) although simulation programs are shown to sometimes increase student learning, teachers need to use care in deciding when to use simulations, which ones to use, and how to use them in the classroom.

Kulik summarizes his report by noting that overall, evaluation studies suggest schools have been more successful in using instructional technology during the past decade than they were in earlier years. Computers have improved, but so have the skills of the teachers and students using them. Recent studies suggest instructional technology is thriving and can make teaching more effective in elementary and secondary schools.

Mann, Shakeshaft, Becker, and Kottkamp (1999) carried out a major study to examine the link between technology and student achievement in West Virginia schools. Data was gathered and analyzed to determine the impact of a Type I ILS, Jostens Learning System, on student achievement in spelling, vocabulary, reading, and mathematics. Because of time and resource restraints, the researchers chose to use 18 schools as their "initial stratifier" from which they would study all students in those schools. The resulting student sample included all 950 fifth-grade students in the 18 stratified schools. Criteria for selection were student technology experience, technology access, school level achievement, geography, software vendor support, and community interest. Results of that study showed that the more students participated in the use of the ILS, the more their test scores rose on the Stanford 9, with lower achieving students' scores improving the most.

Wenglinsky (1998) conducted a statistical analysis on a national sample of 6,227 fourth graders' and 7,146 eighth graders' mathematics achievement on the National Assessment of Educational Progress (NAEP) to determine meaningful relationships among variables and to isolate specific relationships among variables and how they relate to higher order learning in mathematics. This included technology use as a variable of interest and the use of appropriate control groups for comparison purposes.

His study found that when computer programs were used for drill only they had little effect on student performance. Both fourth- and eighth-grade students who used drill and practice technologies performed worse on NAEP than students who did not use drill and practice technology. The study also found that the greatest inequities in computer use are not in how often they are used, but in the ways in which they are used. Higher mathematics scores were related to adequate access to computer technology (hardware, software, and overall infrastructure) in conjunction with teachers trained in technology use and the use of computers to learn new, higher-order concepts.

The research studies described here indicate, not conclusively, that Type I applications such as tutorials, CAI, CBI, and ILS, if implemented and used properly, have been found to improve student scores in several academic content areas.

Type II Studies and Student Outcomes

Educators experienced with educational technology hold the opinion that Type II software, which has more open-ended and learner-controlled characteristics, offer the most promise for improving students' problem-solving and creative skills as well as their academic achievement scores (Bransford, et al., 1999; the CEO Forum, 2001; GLEF, 2001; Jonassen & Stollenwerk, 1999; Pea et al., 2003; and Roschelle, et al., 2000).

Waddoups (2004) reviewed scientifically based research (SBR) studies from major library databases such as ERIC, Current Contents, Wilson, and PsychInfo, as well as studies and reports from the publication archives of regional educational laboratories and other educational and research institutions. Candidate studies were reviewed and categorized as gold, silver, or bronze according to their alignment with SBR criteria published by the U.S. Department of Education (2002) and the National Research Council (2002). He restricted his literature review to studies covering grades K–8 and those published in peer-reviewed publications or by qualified institutions no earlier than 1995. A total of 34 studies met either gold- or silver-level SBR standards. Nine studies met gold-level SBR criteria; there were controlled trials characterized by random sampling for control and treatment groups. Gold-level SBR studies provide "strong" evidence of treatment effectiveness. The remaining 25 studies met silver-level standards. While gold-level SBR corresponds to "strong" evidence of treatment effectiveness, silver-level SBR delivers "possible" evidence.

In his analysis of the 34 studies, Waddoups found 11 general themes associated with the use of technology to improve student learning. While software-based instruction (Type I) could deliver immediate and personalized feedback, more open-ended and integrated technology applications (Type II) were found to be most effective in the context of inquiry-based classroom instruction, with the impact especially pronounced in developing students' higher-order thinking skills. Such inquiry-based instruction was shown to improve math, science, reading, and writing skills. More than one third of the silver-level studies identified a relationship between inquiry-based teaching methods, technology integration, and higher achievement.

Waddoups concluded that the available body of SBR shows that, provided certain conditions are met, integrating technology into classroom instruction with the use of a variety of applications can significantly and measurably improve K–8 students' academic achievement. This effect was found for core subjects such as mathematics, language arts, science, and social studies. Additional collateral benefits of such integration included improved computer skills, problem-solving skills, motivation levels, and attitudes toward learning. Furthermore, these benefits applied to students across all grade levels, including at-risk children.

The George Lucas Education Foundation (GLEF) summarized several studies from the past few years regarding the use of technology in a variety of educational contexts (2001). None of these studies can be considered the "gold standard" of scientifically based research; however, they reveal the many ways that educators are finding that technology enhances learning. Several of the studies that GLEF reviewed are briefly noted below.

One comparison study found that students at a school using project-based strategies, accompanied by technology, did better on math problems requiring higher-order thinking skills than students using traditional methods for solving math problems. The study also found that three times as many students at the project-based school scored in the top percentiles on the national math exam.

Another GLEF study found that students in Challenge 2000 multimedia project (a 5-year study monitored by SRI International) classrooms outperformed students in non-technology classrooms in communication skills, teamwork, and problem solving. Researchers from the Center for Learning in Technology found that students who had been labeled as low achievers were found to have become more engaged in their learning, showing "greater responsibility for learning, increased peer collaboration skills, and greater achievement gains. Students in the multimedia project classrooms "outperformed comparison classrooms in . . . student content, attention to audience, and design" (p. 1).

GLEF reports that in 1992, a group of 700 students prepared projects that involved videotaping problem-based activities over a 3-week period. Later in the school year researchers from the Cognition and Technology Group at Vanderbilt found that students involved in this program performed better in the following competence categories: basic math, word problems, planning capabilities, attitude, and teacher feedback.

Another study described by GLEF is a 1999 study by the Center for Research in Educational Policy (University of Memphis and University of Tennessee-Knoxville). Four of five continuing Co-NECT schools in Memphis demonstrated stronger achievement gains across all subject areas over a period of 2 years (1996–1998) on Tennessee's Valued-Added Assessment System (TVAAS) than a set of control schools. Co-NECT schools gained almost 26% more than the national norm means for the subjects and grades tested.

Studies of the Effects of Teaching and Learning With Technology

In 2002, North Central Regional Educational Laboratory (NCREL commissioned a meta-analysis by Waxman, Connell, and Gray to study the effects of teaching and learning with technology on student outcomes. Several criteria were established for inclusion in this synthesis. The synthesis included quantitative, experimental, and quasi-experimental research and evaluation studies that had been published in refereed journals during a 5-year period (1997–2002). The report calculated 138 effect sizes using statistical data from 20 selected studies representing a combined sample of approximately 4,400 students. The mean of the study-weighted effect sizes averaging across all outcomes was .30 ($p < .05$), with a 95% confidence interval. This result indicates that teaching and learning with technology has a small, positive, significant ($p < .05$) effect on student outcomes when compared to traditional instruction.

In 2003, Waxman, Lin, and Michko extended the study to estimate the effects of teaching and learning with technology on students' cognitive, affective, and behavioral outcomes of learning. This study quantitatively synthesized experimental and quasi-experimental published research on the effects of teaching and learning with technology on student outcomes in naturalistic settings. The final sample of studies included 42 journal articles. A total of 282 effect sizes were calculated for a combined sample of approximately 7,000 students. The mean of the study-weighted effect sizes averaging across all outcomes was .410 ($p < .001$), with a 95% confidence interval (CI) of .175 to .644. This result indicates that teaching and learning with technology has a small, positive, significant ($p < .001$) effect on student outcomes when compared to traditional instruction. The mean study-weighted effect size for the 29 studies containing cognitive outcomes was .448, and the mean study-weighted effect size for the 10 comparisons that focused on student affective outcomes was .464. On the other hand, the mean study-weighted effect size for the three studies that contained behavioral outcomes was -.091, indicating that technology had a small, negative effect on students' behavioral outcomes. The overall study-weighted effects were constant across the categories of study characteristics, quality of study indicators, technology characteristics, and instructional/teaching characteristics.

In general, researchers have found that technology's impact on student learning is difficult to gauge, especially with Type II applications. The skills that Type II applications can effect, such as higher-order thinking and research ability, are more difficult to measure in a quantifiable way. Another impediment is that technology and its uses change so quickly that technology use in schools today is very different from technology use 4 or 5 years ago, suggesting that its impact may have changed as well. Yet another reason for the lack of clear research is that the effectiveness of Type II applications relies on the expertise of the user, on the expertise of the teacher to use it effectively as a teaching tool, on the administrator to use it effectively as a data resource, and on the design of the tool itself.

Waxman et al. (2003) found that in general the available research related to teaching and learning with technology lacked quality. Few quantitative studies used randomized, experimental design. The studies also lacked details such as specifics about software and technology components.

Heinecke et al. (1999) recommends a more formative approach for evaluating the effectiveness of educational technology and for recognizing its complexity and ever-changing nature. Multiple measures (quantitative and qualitative) should be used in order to get at the complexities of the learning process as it interacts with technology processes. Evaluation design should incorporate longitudinal studies of cohorts of students over several years and should rely less on participants' self-reported attitudes and more on observations of participants' actions within learning contexts. Evaluations should not focus on simple outcomes measures such as posttests but rather should focus on complex metrics describing the learning process, such as cognitive modeling, instructional design, and technology implementation.

Afterschool Research Studies

One of the few studies found regarding students and technology in afterschool settings is a review of the literature from Hall and Israel (2004) that explored the use of technology to support academic achievement for at-risk teens during out-of-school time. Their paper produces insights into this important topic; however, the authors did not describe the types of studies and documents that they included in their final synthesis. They did describe their extensive search method for publications, research briefs, theory and practice pieces, and observations, which yielded approximately 235 documents for initial review, with 132 of those documents (not described) included in the final paper. Their search focused on three areas: at-risk teens, out-of-school programs, and technology as a support to academic achievement. They considered publication dates as well as content and scope when selecting the documents for final review and decided to focus on literature published within the last 10 years. A search of publications, research briefs, and observations yielded little literature that combined the three areas of their focus. Therefore, in their final paper, Hall and Israel summarize the literature separately in three sections and then synthesize the three areas into a single discussion and summary.

In section one, the researchers summarized but did not describe the type of studies regarding at-risk teens and academic achievement. A reference to the Waxman, Padron, and Arnold study (2001) describes five practices shown to improve the education of at-risk students: "1) cognitively-guided instruction, 2) culturally responsive teaching, 3) technology-enriched instruction, 4) cooperative learning, and 5) instructional conversation" (p. 3). Many of these practices are supported by much of the literature about at-risk teens.

A study by Norris (1994) cited, but not described, proposed similar strategies: "1) individualized instruction facilitated by computer–based instruction, 2) collaborative learning, including learning that employs computer-based simulations, computer conferencing, and database access, 3) peer tutoring, which can focus on the study of technology itself, and 4) teaching across the curriculum through computer simulations that incorporate topics in math, language arts, and science in the same lesson" (p. 4).

A reference to Means (1997) "concludes that strategies that use technology to teach real world applications that support research, design, analysis and communication will support at-risk students" (p. 4). The Day study (2002) (also not described) studied at-risk middle school students who were given the opportunity to work in a computer lab. Day found that those students were more motivated, made better grades, and accepted responsibility for their class work in the lab and that they felt better about themselves.

The literature in section two from Hall and Israel focuses on technology, teens, and academic achievement. Differences between gender and race regarding use of computers and the Internet were discovered and yielded two important implications for program and instructional design. The first is that teens "with little experience in using technology may be less likely to engage in learning tasks that rely on technological skills and experience. They may also be less attracted to programs highlighting technology experience, expecting that such would be a mismatch to their interests or background" (p. 7). A second implication is that afterschool programs offer a desirable opportunity for technology experiences because "the youth that have fewer technology opportunities are the same youth most often served by out-of-school time programs" (p. 8).

In the third section, Hall and Israel focused on out-of-school programs, academic achievement, and technology. Like the authors of this review, they found quite a lot of literature on effective strategies for using technology to support learning and ways to integrate technology into teen programs but limited research regarding use of technology and its impact on academic achievement in afterschool programs.

However, Hall and Israel point out that "out-of-school time program settings can resemble, both in environment and content, in-school settings," suggesting that findings from regular school day studies can be applied to use of technology as a learning tool in afterschool (p. 8). On the other hand, Hall and Israel point out that afterschool programs function differently than regular day school with their mixed-age groups, small-group learning, flexible schedules, and frequent opportunities for real-world activities. Hall and Israel suggest that future research studies consider the uniqueness of the afterschool setting and investigate how a technology program is best implemented.

While limited in its scope and design, an evaluation study (Liu, 2002) conducted by the Urban Institute of the District of Columbia 21st Century Community Learning Center (CCLC) program offers a glimpse into the DC afterschool technology program. The study describes the implementation of technology into a summer program and monitors staff and students from 10 schools during that time frame. The goal of the technology program was to see how and if technology could improve academic achievement in math and reading for students in grades 6–10. Data for the report were gathered from several sources: written documents and reports; observations of activities; interviews; and focus groups. The report documents two computer software applications used for the program, ReadProg and MathProg, both Type I self-paced tutorial applications used for remedial purposes. ReadProg sessions ranged from 45 minutes to 1.5 hours. MathProg sessions ranged from 1 hour to 5 hours. Most teacher/facilitators reported that they were comfortable monitoring the students during the sessions but did not claim to be very experienced with other computer applications. Students' progress was reported regularly through the computer software, and students often received incentives from the teachers.

The level of overall engagement of students was initially high, but in a final analysis and through focus groups, many students reported their dissatisfaction with both the math and reading programs, saying they were "boring, repetitious, and pointless." Motivation and engagement were observed as decreasing as class periods lengthened. When students were not actively engaged with the programs, they frequently chose to surf the Internet and often were observed accessing pornographic sites and other unapproved sites.

Several management problems were noted: the late announcement of the program start, low interest, low enrollment, and low attendance. Implementation and use of the computer programs also revealed several problems: non-acknowledgement of student's prior individual skills, slow pacing through the course levels, guessing on multiple choice items, repetitious lessons, reuse of the same tests, and easily available answers for homework. Further interviews found that 27 of the 33 students had computers at home, and computer use outside of school was varied but generally very high. These problems possibly contributed to the students' overall lack of interest and enthusiasm for the program.

While the research indicates that a tutorial (Type I) computer program such as the ones described above can raise achievement levels in math and reading, this particular case is an example of how improper implementation can prevent reaching desired goals. It is also unfortunate that this afterschool program has chosen for its technology program a poorly disguised remedial homework session. Many studies offer compelling results regarding the positive effect on academic achievement with the use of technology. However, this evaluation study of the DC 21st CCLC shows drawbacks to improper technology use. The mere presence of technology does not guarantee effective learning and desired results. As shown here, inappropriate instructional planning and guidance can actually limit instruction and detract from instructional goals and objectives. The primary point consistently found in the research is that it is not the presence of technology but how the technology is used as a learning tool that makes a difference. Many researchers recommend that technology tools must be a part of a intentional education approach. (Speziale, 2003; National Research Council's Committee on Improving Learning with Technology, 2003; Ringstaff & Kelly, 2002; SIIA, 2000; Soloway et al., 1998).

The results of a study conducted in 2006 by the National Center for Research on Evaluation, Standards, and Student Testing (CRESST) for the National Partnership for Quality Afterschool Learning indicate that using technology regularly in afterschool programs to support learning in several content areas leads to improved motivation, attitudes, and academic achievement (Huang, 2007). This same study also indicates that such elements as student characteristics, teacher skills, access to technology, effective planning, and administrative support and leadership are essential to technology planning.

CRESST used a multimethod approach to data collection and analysis that combined both quantitative and qualitative data, including staff and parent surveys; in-depth interviews with program directors, site coordinators, principals, and instructors;

and direct observation of classroom instruction (Huang, 2006). The purpose of the study was to identify characteristics of "promising" instructional practices in six different content areas, including technology, in 104 sites from 53 high-quality afterschool programs across the United States. Project-based learning was the core of the technology instruction in 70% of the programs, with all programs using learning through doing and hands-on methodologies (Huang, 2007).

SECTION IV
DISCUSSION

The available body of evidence-based research and numerous meta-analyses examining the effect of educational technology on education conducted over the past several years indicate that provided certain conditions are met, integrating technology into classroom instruction can significantly and measurably improve K–12 students' academic achievement in core subjects such as mathematics, language arts, science, social studies, and other subjects.

Waddoups's (2004) synthesis of gold-level scientifically based research indicates that the use of technology in K–8 classrooms can lead to improved motivation, attitudes, and academic achievement in students but does not necessarily guarantee those results. Eleven of the recurring themes from the 34 gold- and silver-level studies that Waddoups reviewed point to the following four technology integration principles (pp. 4–5):

1) Teachers, not technology, are the key to unlocking student potential and fostering achievement. Teachers' training in, knowledge of, and attitudes toward technology are central to effective technology integration.
2) Curriculum design is critical for successful integration. Several studies emphasize the effectiveness of integrating technology into an inquiry-based approach to instruction.
3) Technology design must be flexible enough to be applied to many settings, deliver rich and timely feedback, and provide students multiple opportunities to engage with the content.
4) Ongoing formative evaluations are necessary for continued improvements to integrating technology into instruction.

The National Research Council's Committee on Improving Learning with Technology (2000) and other researchers recommend the following types of activities that suggest the use of Type II software applications:

- Active engagement that supports learning in real-world contexts, such as with inquiry projects that allow students to collect scientific data in the natural environment

- Learners connected to experts and communities of other learners
- Participation in collaborative groups
- Visualization and analysis tools with scaffolds to enable students to utilize complex data for higher-order thinking
- Opportunities for feedback, reflection, and revision in the acquisition and construction of knowledge, such as with intelligent tutoring systems
- Expanded opportunities for teacher learning, using methods such as online communities of practice and best-practice case studies

The research studies reviewed in this paper suggest that technology can be an important learning tool for use in schools and other traditional and non-traditional educational settings. Researchers also suggest that appropriate technology choices should always be guided by learning goals and outcomes as well as the interaction of other elements such as software design (Type I versus Type II), student characteristics, teacher skills and professional development, access to technology, long-term planning, and administrative support and leadership. Wenglinsky (1998) found that computers are neither a cure-all for problems facing the schools nor mere fads without impact on student learning. When used properly, computers may serve as important tools, especially for improving student proficiency in mathematics and the overall learning environment of the school.

SECTION V
SUMMARY

The goals of this paper are to show how technology can be used as an effective tool in afterschool settings to support academic content and quality instructional practices. Based on available research, the use of technology in afterschool settings should:

- motivate and engage students in authentic, real-world, relevant activities;
- be integrated into the curriculum to support learning in content-specific areas such as math, reading, science, art, and homework;
- promote student-centered activities where the student becomes involved in determining the course of his or her own learning;
- promote opportunities for communication and collaboration in problem-solving activities;
- offer learners the opportunity to address civic, cultural, and community issues;
- support different learning styles;
- support activities that promote higher-order thinking skills; and
- be safe, operational, and accessible to all.

Recommendations

The Road Ahead program from the National Foundation on the Improvement of Education (2000) strongly endorses technology as a worthwhile investment for public education and makes the following recommendations for designing a school-based technology program effort:

- Start with what you want to achieve. Let desired student outcomes guide technology selection and use. Clear academic goals should govern so that the focus is on outcomes and achievements rather than on dazzling technological tools.
- Remember that innovative programs need 3–5 years to show results.
- Invest in professional development, ongoing teacher-defined and teacher-led training, and student-led training. Provide the time, sustained training, and development for teachers to learn how to use technology to improve their teaching, upgrade their current skills, and integrate technology into basics and core academics.

- Keep in mind that technology supports critical thinking, which should be a focus of the effort.
- Involve others. Success requires the involvement of many stakeholders, the inclusion of administrators at every step of the way, and the work of experienced teams for systemic and long-term planning.
- Provide access to modern computers, educational software, and the Internet for all afterschool participants, allowing them to have access to new learning opportunities and acquire technology and information management skills.
- Use your technology resources after school, on weekends, and in the summer to help students enrich their learning and assist parents and grandparents in learning to use computers.

SECTION VI

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SECTION VIII

A DESCRIPTION OF RESEARCH STUDIES REFERENCED IN THIS PAPER

Author/Researcher/Date	Type/Purpose	Source
DeBell, M., & Chapman, C. (2003, October).	Statistical analysis report that examined the use of computers and the Internet by American children and adolescents between ages 5 and 17.	*Computer and Internet use by children and adolescents in 2001: Statistical analysis report*. Washington, DC: U.S. Department of Education.
George Lucas Educational Foundation. (2001).	Several evaluation studies that document ways that technology enhances learning. Four studies are described in this paper	*Project-based learning research*. Retrieved June 22, 2007, from http://www.edutopia.org/project-based-learning-research
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SECTION IX

APPENDIX

National Educational Technology Standards for Students: The Next Generation

1. **Creativity and Innovation**
   Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students:
   a. apply existing knowledge to generate new ideas, products, or processes.
   b. create original works as a means of personal or group expression.
   c.. use models and simulations to explore complex systems and issues.
   d. identify trends and forecast possibilities.
2. **Communication and Collaboration**
   Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students:
   a. interact, collaborate, and publish with peers, experts or others employing a variety of digital environments and media.
   b. communicate information and ideas effectively to multiple audiences using a variety of media and formats.
   c. develop cultural understanding and global awareness by engaging with learners of other cultures.
   d. contribute to project teams to produce original works or solve problems.
3. **Research and Information Fluency**
   Students apply digital tools to gather, evaluate, and use information. Students:
   a. plan strategies to guide inquiry.
   b. locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
   c. evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
   d.process data and report results.
4. **Critical Thinking, Problem-Solving & Decision-Making**
   Students use critical thinking skills to plan and conduct research, manage projects, solve problems and make informed decisions using appropriate digital tools and resources. Students:
   a. identify and define authentic problems and significant questions for investigation.
   b. plan and manage activities to develop a solution or complete a project.
   c. collect and analyze data to identify solutions and/or make informed decisions.
   d. use multiple processes and diverse perspectives to explore alternative solutions.
5. **Digital Citizenship**
   Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students:
   a. advocate and practice safe, legal, and responsible use of information and technology.
   b. exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
   c. demonstrate personal responsibility for lifelong learning.
   d. exhibit leadership for digital citizenship.
6. **Technology Operations and Concepts**
   Students demonstrate a sound understanding of technology concepts, systems and operations. Students:
   a. understand and use technology systems.
   b. select and use applications effectively and productively.
   c. troubleshoot systems and applications.
   d. transfer current knowledge to learning of new technologies.

Technology as a Tool - Type I and II Applications

for Creation, Communication, Exploration, Investigation, Discovery, and Building Skills

Type I Applications *(1)*	***Type II Applications*** *(1)*
1. Almost everything that happens on the screen and the interaction between user and machine is predetermined by the developers of the software. 2. Students learn “from” the computer, which generally functions as a tutor. 3. Often used to diagnose and teach basic skills in a content area. 4. Instruction is organized around specific objectives and often embodies a mastery approach to instruction. 5. Sometimes described as “full.”	1. The user, rather than the software developer, is in charge of the interaction with the content. 2. Students learn “with” the computer when using this type of application. 3. Usually aimed at accomplishing tasks such as personal productivity, creating products and projects, communication, investigation, and discovery. 4. It can take many hours of use before the user masters everything that a specific program is capable of doing. 5. Sometimes described as “empty.”
Types __Drill and practice __Computer-based instruction - CBI __Computer-assisted instruction - CAI __Tutorials __Integrated learning system - ILS __Games____________________ ________________________ ________________________ ________________________	***Types*** __Word processing __Electronic presentations __Electronic spreadsheets __Digital multimedia __Internet __E-mail __Concept mapping __Music __Simulations
Product Names __Cognitive Tutor (Algebra) __PLATO __Waterford Early Reading Program, __Success Maker __Odyssey	***Product Names*** __Microsoft Office Suite - Word, PowerPoint, Excel __Inspiration (concept mapping) ________________________ ________________________ ________________________
Instructional Uses ________________________ ________________________	***Instructional Uses*** ________________________ ________________________

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