April 2002
SRI Project 11060

USING TECHNOLOGY TO ENHANCE CONNECTIONS BETWEEN HOME AND SCHOOL

A RESEARCH SYNTHESIS

Prepared for:

Planning and Evaluation Service, U.S. Department of Education
DHHS Contract # 282-00-008-Task 1

Prepared by:

William R. Penuel
Deborah Y. Kim
Vera Michalchik
Sarah Lewis
Barbara Means
Robert Murphy
Christine Korbak
Alexis Whaley
Jacob E. Allen

Table of Contents

Overview

As families' access to advanced computer and telecommunications technologies has increased, new opportunities to forge home-school connections supported by new and advanced technologies have become possible. Many new programs have been implemented in recent years that make available to students desktop computers for use at home. Other programs provide laptop computers that can be taken back and forth between home and school. Still other programs are aimed at linking families with schools through the use of the Internet and other information technologies, providing parents with up-to-date information on school events or their children's progress in school.

Although evaluation studies of some of these programs' effectiveness have been conducted, to date there have been no comprehensive reviews of these studies. Most of these studies do not appear in published journals and can be difficult for decision-makers to find. Leaders in schools, districts, and state departments of education need data on program effectiveness and on issues faced by schools when implementing these kinds of programs to make good decisions about where to invest technology dollars. Researchers and evaluators need to be able to identify and understand gaps in knowledge of programs' effectiveness, in order to design future evaluation studies that address these gaps.

The purpose of this report is to synthesize research on the effectiveness of programs that use technology to improve links between home and school, with the aim of guiding future evaluation and policy. To develop this report, we conducted a comprehensive review of research on the subject of technology-supported programs that link home and school. We also gathered data from interviews and observations of selected programs to learn more about how the programs are implemented and their prospects for sustainability and replicability. The report also includes findings from case studies of eight programs conducted in spring 2001.

The research base from which we drew was relatively small, because there have been few outcome studies that have examined these programs' effectiveness, in terms of either enhancing student achievement or increasing parent-school communication. The research designs used in most of these studies, moreover, make it difficult to draw conclusions about whether providing technology access to students through desktop or laptop programs causes increases in student achievement or whether using existing technology access to promote greater parent involvement causes improvements in parent-school communication. Only 19 studies that examined outcomes could be identified. Just 2 of the 19 outcome studies included in the review relied on experimental designs. Of the remaining quasi-experimental studies reviewed, 10 attempted to ensure that treatment and comparison groups were similar at the outset of the study, and 7 studies did not examine the match between treatment and comparison groups at all.

There were other important shortcomings of studies included in the review that limit their usefulness in guiding policy and research. Few studies measured both outcomes and program implementation levels, making it impossible to examine the degree to which the depth of implementation contributes to specific gains. In addition, some of the studies did not report information needed to estimate the effects of the programs they were evaluating.

This report attempts to synthesize the best evidence (Slavin, 1986) available from the research conducted, taking into account the methodological limitations of the knowledge base of studies included in the review. Across the studies that did meet methodological criteria for inclusion in the review and that reported data needed to calculate effect sizes, there was evidence that program participation and student and parent outcomes were linked in ways that bear further investigation in new, rigorously designed studies. In particular, the mean reported positive effects of programs on students' writing skills are similar in magnitude to those of other educational interventions, such as the reported effects of computer-assisted instruction on achievement. Mean positive effects on mathematics achievement and parent-school communication are similar to reported effects of reducing class size from 24 to 15 students. (However, studies that measured these outcomes reported no effects and positive effects for equal numbers of programs.) The associations between laptop program participation and higher levels of technology proficiency are even greater. Each of these reported effects is suggestive of the potential of programs that use technology to link home and school, but the failure of many studies to account for prior differences in student achievement between treatment and comparison groups, the paucity of experimental designs, and the lack of information on implementation make it risky to attribute the improved outcomes to the use of technology per se.

The specific contribution of technology is difficult to measure because many of the programs studied that used technology to link home and school were embedded within larger school reform efforts. In fact, on the whole, these were the programs that reported the largest effects. In these programs, technology was intended to support or augment initiatives aimed at increasing expectations for all students, transforming teaching practices, or developing students' literacy. Evaluation results from these studies suggest that although it may not be easy to determine whether greater access to technology at home in itself makes a difference, enhanced home access may work in combination with larger reform efforts to improve learning outcomes for students.

The research synthesis examined issues related to implementation for each type of program, as well. SRI researchers collected case study data on program implementation from eight sites to identify issues that might affect program outcomes. The eight sites represented both programs that had been studied by researchers or evaluators included in this review and new programs that have not yet been evaluated. Common to several programs' concerns were needs for adequate technical support, teacher professional development, strategies for addressing inequities of access to technology within programs, and stronger links between the school and home components of programs.

We recommend that future research in this area adhere to emerging standards for reporting data in the social sciences in ways that allow for comparison of research findings across studies. Standards such as those proposed by the American Psychological Association (1994), the Campbell Collaboration (Boruch, Petrosino, & Chalmers, 1999), and the Cochrane Collaboration (Clarke & Oxman, 2001) all point toward the same recommendation: that researchers report information needed to aid independent researchers in research synthesis. Whether the audiences of a research report are policy-makers or members of the research community, using shared conventions for reporting the results of a study aids in the assessment of individual study findings and makes the report more useful as a foundation for building knowledge in educational research.

Second, more rigorously designed studies that can more effectively test claims that program participation leads to improved student or parent outcomes are needed. A variety of studies are needed, including studies that use random assignment to treatment and control groups and studies that are designed to test the effectiveness of particular implementation models. These studies need not isolate technology's effect per se to be useful to policy-makers; several studies in this review suggest that technology's effective use depends, at least in part, on being well aligned with larger reform efforts aimed at improving student achievement.

The study authors also recommend new research in two areas. First, research is needed to investigate the cost-effectiveness of programs. Many programs remain costly for schools and districts to implement; determining whether low-cost alternatives to desktop and laptop computers might be just as effective is an important area for evaluators to consider. Second, research is needed to investigate how technologies are used at home. To the extent that the educational effectiveness of providing students with laptop computers that can be taken back and forth between home and school depends on students' effective use of these computers at home, we need a better understanding of how students are using laptops at home.

Background

Overview and Summary of Background Section

Young people's access to advanced computer and telecommunications technologies at school and in the home is increasing at a rapid pace. In 1984, just 8% of all households owned a home computer, but by 2000, an estimated 51% did (U.S. Census Bureau, 2001). Internet access in American households is increasing as well: by 2000, it was estimated that 42% of all households had access to the Internet at home (U.S. Census Bureau, 2001). In homes with school-aged children, the percentage of households with computers (57%) was roughly the same in 1998 as the percentage of classrooms with computers (51%) (Becker, 2000). At the same time, the percentage of classrooms with access to the Internet remained much higher than the percentage of homes with Internet access (National Center for Education Statistics [NCES], 2000).

New information technologies have far-reaching potential for improving education, including increasing students' engagement and time on task, transforming teaching practice, and creating new forms of parent involvement. In addition, researchers have found that patterns of home access and use of new technologies are related to what happens to students in school. Inequities in access to computers and the Internet may affect student achievement, and, to the extent that more assignments in class and homework require the use of the computers, the impact could be direct and strong.

Programs designed to improve students' access to technology at home have been implemented both to address these inequities in access and to improve student achievement. Other programs make it possible for parents and their children to use what technology they have in their homes more effectively to communicate with the school or to involve parents more in their children's learning.

Home Access to Computers and Student Achievement

In the past decade, a number of researchers have studied how computer use in schools can improve student performance. Researchers report increased levels of student engagement in classrooms where teachers are using technology to support authentic, student-centered instruction (Means & Olson, 1995; Sandholtz, Ringstaff, & Dwyer, 1997). Other researchers have investigated the relationship between classroom computer use and extended time on task, a factor strongly linked to student achievement (see Allen & Mountain, 1992; Thomas & Rickhuss, 1992). Studies of computer-assisted instruction that provides students with extended opportunities to practice reading or solving mathematics problems have found that use of these technologies has been associated with gains in basic skills achievement (Kulik & Kulik, 1991).

Studies of *home* use of technology by students are far less numerous than studies of school computer use, but they have examined effects similar to those found in research on school use. For example, these studies have examined students' engagement with educational software and use of computers to extend learning time at home. Although one early study of home use of technology argued that students used computers for academic reasons only sporadically (see Giacquinta, Bauer, & Levin, 1993), more recent data from the U.S. Census Bureau (1999) suggest that although games are students' primary use of computers in the home, the second most often cited use is for school assignments. Parents cite education as the main reason for buying a home computer, and students rank education as the most important reason for using the Internet at home (National School Boards Association, 2000).

Researchers also have examined relationships between home computer use and student achievement. A study by Rocheleau (1995) used data from the National Science Foundation's Longitudinal Study of American Youth to examine the relationships among home computer access, home computer use, and student achievement. Rocheleau found higher overall grades and higher grades in mathematics and English among students who had access to a computer at home, compared with those students without home access. Among the students in Rocheleau's study who had a computer at home, there were significant differences between heavy and infrequent users of computers. Students who used technology at home more frequently had significantly higher mathematics grades, on average, than infrequent users of technology at home. By contrast, Wenglinsky's (1998) cross-sectional analysis found a negative association between home use of computers and mathematics scores on the 1996 National Assessment of Educational Progress among 4th-graders. Wenglinsky found a small positive association between home use and achievement among 8th-graders.

Other studies have presented evidence that students with home access to computers also may achieve higher levels of technology proficiency. Sparks (1986) found that 7th-grade students who had home computers significantly outscored a comparison group of students in the same schools who did not have access to computers at home on a measure of technology skill. More recently, one study found that students with home computers had more positive attitudes toward computers than did students without home computers (Selwyn, 1998). In an examination of results from a test of technology proficiency administered statewide to students in North Carolina, researchers found that students with home access to computers "all the time" were more likely to pass the state's proficiency test than were students with home access "on occasion" or students with access only at school (North Carolina Department of Public Instruction, 1999). The study also found that students who said they learned how to use computers at home were more likely to pass the test than those students who reported learning how to use computers at school. These results suggest that the contribution of technology access at home to development of technology proficiency may be just as critical as that of access to technology at school.

Inequities in Home Access and Use of Technology

Patterns of technology access in students' homes are not similar across all groups of Americans. Despite large increases in computer and Internet access over the past decade, disparities in access remain among different ethnic groups, income levels, types of households, ages, and disability statuses (National Telecommunications and Information Administration, 2000). The National Telecommunications and Information Administration's (NTIA) study of the digital divide found that in 1999 households with higher incomes in urban areas were more than 20 times as likely as rural households at the lowest income levels to have access to the Internet (NTIA, 1999). In addition, African American and Hispanic households were two-fifths as likely than White households to have access to the Internet (NTIA, 1999). Households where an adult used a computer at work also were more likely to have access to the Internet at home (NTIA, 1999). Rural Americans, regardless of income, were half as likely to have access to the Internet, and differences in availability of broadband connectivity between urban and rural areas are striking (NTIA, 1999; NTIA, 2000).

A recent analysis by Becker (2000) identified a number of other important differences among groups in home access to technology. Parent education levels are predictive of technology access in the home: as of 1998, only 16% of children living with parents who did not complete high school had access to a computer at home, compared with 91% of children who had a parent with at least a master's degree. Households with one parent and blue-collar households were less likely to have home computers. These factors play an even greater role in predicting the *quality* of home access to technology. Fewer than one-third of children whose parents were not high school graduates, even if they had a computer at home, were likely to have a computer with broad functionality for running contemporary programs (e.g., spreadsheets, word processing software), compared with two-thirds of children who had a parent with at least a bachelor's degree.

Home *use* of computers also is not the same for persons of different ages, ethnicities, parent education levels, family income levels, or genders (U.S. Census Bureau, 1999). Older children are more likely than younger children to use computers at home, and White children are more likely than African-American and Hispanic children to use computers at home. Home use is more likely for children of parents with a bachelor's degree or higher and for children from high-income (= $75,000) households than for children from low-income families (= $25,000) (U.S. Census Bureau, 1999). A number of studies have examined gender differences in home use of technology. Reinen and Plomp (1997) found that fewer girls than boys used computers at home. A Roper survey in 1998 similarly found lower home computer ownership and use among girls than boys (Chiaramonte, 1999).

Promoting Achievement and Equity by Providing Computer Access

The impact of differences in *home* technology access and use on *school* technology use is not well understood. On the one hand, researchers have found that in schools where there are high concentrations of low-income students, computer use tends to emphasize drill and practice software available at school and focus less on more advanced uses of technology, such as multimedia authoring or simulation tools (Wenglinsky, 1998; Becker & Anderson, 2000). By contrast, teachers in schools with students from middle- and upper-income families are more likely to use computers in classrooms to teach students to analyze, synthesize, and present information to others (Becker & Anderson, 2000). One interpretation of these data (Becker & Anderson, 2000) has been that teachers' different *goals* for student learning shape these different uses of technology. Other data suggest that school technology expenditures on equipment, training, and support influence teachers' decisions on how to use technology in school (Anderson & Becker, 2001). It is plausible as well that teachers' understanding of what kinds of technologies are available in students' homes could similarly influence their assignment of more complex work.

There is also little agreement among researchers as to whether improving home access to technology is associated with improvements in educational outcomes. Certainly, the potential for impact on student learning is expanded by greater access to technology, whether because teachers give more complex assignments to students that require the use of technology or because students spend more time on task writing with a word processor or analyzing data from scientific experiments with spreadsheets, for example. In addition, the potential is great to expand opportunities for parents to become involved in their children's learning by providing joint activities on the computer or making communication easier with voicemail or Web-based technologies.

In the past 5 years, a number of researchers have begun to investigate the potential of technology to link home and school. These researchers have investigated the effects in a few of the hundreds of schools and districts that have implemented programs that make it easier for students to obtain their own computers for use at home and at school. Some of these programs, as one of their primary goals, strive to reduce inequities in technology access, especially for low-income students whose families are less likely to have a computer at home. Programs sometimes also believe that providing students with their own computers will increase their motivation to learn; the hope is that increasing technology access at home will improve student achievement. Other programs see such initiatives as opportunities to reform teaching and learning in a school or district; they may provide extensive professional development to teachers and training to parents to prepare the school community for transformation.

For this report, we reviewed studies about and visited two different kinds of programs that provide home access to technology: home desktop programs and laptop programs. One other type of program that is becoming increasingly popular in schools and community centers, computer recycling and repair programs, was excluded from the review.[1] As computer prices fall or new low-cost alternatives to providing 1:1 technology access for students become more widely available, all these types of programs are likely to increase in popularity.

Home Desktop Programs

Early attempts to improve home access to technology focused on providing students with home desktops, often with connections to an online communications network. These home desktop programs aimed to improve student motivation and achievement, make technology more accessible to low-income students, and, in some cases, encourage students to aspire to lifelong learning goals, including higher education. They sometimes included a school component for participants, but students could not bring their computers back and forth between home and school. Three of the home desktop programs described in this report were programs lasting several years. These programs

[1] These programs typically involve students in learning how to repair or refurbish older computers. The computers, once repaired, may be taken home by the students themselves or donated to other families in the school who lack computer access. One group organized to support these programs nationally, the LINCT Coalition, has grown from three partners supporting a single community in Long Island to nine partners serving 13 large urban areas nation wide in just 5 years (Komoski, 2001). To date, there have been no evaluation studies of these types of programs. More information about these programs can be found at http://www.linct.org.

proved to be sustainable over extended times because of a combination of strong support from policy leaders and corporate partnerships.

Today's desktop programs may rely on similar kinds of support, but they also may rely directly on corporate donations of computers and staff from local nonprofit agencies. Like earlier programs, they serve students in low-income communities, aiming to provide computers and introductory training to families least likely to have a computer at home. In addition to providing training and technology access, they often also provide free or low-cost Internet access and email accounts to families.

Laptop Programs

When they could afford to buy a large number of computers, many schools throughout the 1980s and early 1990s placed them in centrally located laboratories (Means & Olson, 1995). Computer use in labs has been found to be effective at least over the short term (Kulik & Kulik, 1991), but researchers have long argued that for technology to make a powerful difference in student learning, students must be able to use computers more than once or twice a week in a lab at school (see Kozma, 1991).

Laptop programs in K-12 education gained popularity in Australia a few years before they began to take root in the United States (Stevenson, 1998; M. Cullinane, Microsoft Anytime Anywhere Learning Program Manager, Personal Communication, July 2001). Schools provided students with laptops they could take home or use at school, creating opportunities for more intensive uses of technology and creating a 1:1 ratio of computers to students. Inspired by the success of these programs, Microsoft and Toshiba created the Anytime Anywhere Learning program in 1996, designed to promote the use of laptops in K-12 schools, both in the United States and abroad. As part of this program, scores of schools and districts have implemented laptop programs. Parallel to these efforts, many colleges and universities have implemented laptop programs that include requirements to purchase or lease a notebook computer for all students.[2]

---

[2] For a list of notebook colleges and universities, see http://www.acck.edu/%7Earayb/NoteBookList.html. [accessed 8/24/01]

Schools and districts differ in their goals for laptop programs. Nearly all expect the laptops to result in improved student learning, whether that effect is direct (e.g., higher test scores) or indirect (e.g., increased student motivation). But many programs also have the explicit goal of reducing inequities in computer access between low and higher-income students. In Beaufort County School District in South Carolina and District 6 in New York City, laptop programs are aimed at providing computer access for low-income middle school students who are least likely to have a computer at home. In these programs, creating a 1:1 ratio of students to computers is not just a way to encourage more intensive technology use, it is a strategy for creating equity in educational opportunity.

Laptop programs also differ from one another in their vision for technology's role in student learning. Many laptop programs are *cross-curricular,* in that they encourage teachers across the school or district to integrate technology throughout the curriculum. They expect students to use computers as research, productivity, and communication tools for assignments in all their courses. A few programs are *subject-matter specific,* targeted to improvements in just one or two subject areas, such as writing or science. Special software may be loaded on the laptops that helps students organize their writing, revise their work, or visualize phenomena that are difficult to understand. Still other laptop programs are *reform embedded.* In these programs, laptops are not seen as the primary tool for transforming teaching and learning; instead, laptops are only one strategy within a comprehensive program of reform within a school, district, or state.

A third important way that laptop programs differ from one another is with respect to their strategy for funding. Some programs finance laptops for students directly. Funding for the program may come from district curriculum or technology funds, grants, federal or state discretionary funds, or even bond initiatives. In many programs, parents are expected to pay a portion of the costs of the computer. In these programs, parents sign a multiyear lease agreement with a district. They pay a monthly fee, anywhere from $10 to $50, to the district, and when the lease is up, they have the option to keep or buy the laptop, provided they have made all payments to the district. Some districts use a sliding scale to determine lease costs to families to make payment easier for low-income families.

Although there are no sources of official data that compare the numbers of laptop and home desktop programs, attention from the media has focused greater attention on laptop programs. As costs of laptops approach what desktops cost just a few years ago, laptops have become more viable alternatives for schools and districts to consider. At the same time, debate continues over the relative merits of laptops, desktops, and other emerging low-cost alternatives to providing technology access. For example, the advantage of desktop computers over laptops, according to their advocates, is greater security (since the computer stays in the student's home), better durability (desktops tend to break less often), and lower cost (desktops are often half the price of laptops). At the same time, students cannot use home desktops in the classroom for note taking or for work on current assignments.

There have been a number of studies of laptop programs' effectiveness, as well as numerous articles and Web sites devoted to helping schools design and implement laptop programs. Twelve effectiveness studies are included in this research synthesis. It is important to note that these studies are of programs with widely differing designs—a fact that has important implications for the design of evaluations (e.g., selection of appropriate outcome measures). Although it is not our purpose to describe the ideal design of a laptop program in this report, our review and case studies did reveal important implementation, scalability and replicability issues that are discussed in subsequent sections of this report.

Using Existing Access to Promote Parent Involvement

While laptop and home desktop programs aim to improve access to technology to meet their goals, other program types build on and rely on access to computers and the Internet that families already have in their homes. Many of these programs are equally focused on improving student achievement; others target parents more directly, seeking to involve them more in their children education or to enhance parent-school communication. Programs aimed at increasing parent involvement follow strategies consistent with those of other programs, such as Title I parent compacts (Funkhouser, Stief, & Allen, 1998) and parent and teacher education programs, which are aimed at building closer ties between home and school. Technology has the potential to augment such programs by providing an easy means for communication anytime, anywhere between parents and teachers (Bauch, 1994). For this report, we reviewed studies about two types of programs in this area, discrete educational software for the home and voicemail programs, and we conducted site visits to another type, commercial vendors targeting home-school communications. Two other types of programs, joint parent-student projects and adult skill-building programs, were excluded from the review. We found no studies that documented their effectiveness and no widely publicized promising programs to visit.

Discrete Educational Software for the Home

Researchers have long emphasized the importance of involving parents in their children's learning process (Goldenberg, 1987; Scott-Jones, 1987; Stearns & Peterson, 1973). Forms of parent involvement vary from monitoring progress in school to discussing expectations for the future to engaging in joint parent-child activities. A review of quantitative studies found a moderate relationship between parent involvement and student achievement (see Fan & Chen, 2001, for a recent meta-analysis).

In the area of reading, research has pointed to the value of participation in joint learning activities at home. Most studies in this area have examined the impact of joint activities that do not involve technology at all (see Snow Barnes, Chandler, Goodman, & Hemphill, 1991; Tizard, Schofield, & Hewison, 1982). More recently, however, new technologies are permitting parents and their children to participate in joint learning activities that teach reading and other subjects using computers, the Internet, and other "information appliances" (Norman, 1999) like handheld computers or Sony PlayStations.

One widely used software program that encourages joint parent-child interaction is the Lightspan *Achieve Now* program. *Achieve Now* is interactive software for elementary (K-6) grades that uses visually rich games to teach basic academic skills in reading/language arts and mathematics. The games come on CD-ROM, are also available online for districts that purchase the program, and include an integrated assessment system. Districts can access professional development materials online at the Lightspan site or have company staff provide them with training.

Although many other educational software programs are designed for use by students on their own in the home, this software program is unusual in that it encourages parents to play some of the games with their children. In Wichita, Kansas, for example, schools using the program purchased Sony PlayStation machines for students to take home at the beginning of the year. Students connected these machines to their television sets at home, and each week the classroom teacher sent a cartridge with a game for students to play with their parents or to play on their own as a homework assignment. Parents were expected to return signed check-out cards indicating that their child (or they with their child) had completed the assignment. At the end of each year, the PlayStation machines are returned to the school, to be given out again to students the following year.[3]

This report describes and synthesizes findings from several studies of Lightspan's effectiveness. It is the most widely studied of these kinds of programs and the only program of its kind for which we could identify studies that met the criteria for inclusion in our synthesis (see Study Design and Methodology section below). To be included in the review, the study had to report on student achievement and on the impacts of the program on parent involvement in children's learning process and on parent-school communication.

Commercial Education Products Targeting Home-School Communications

A survey conducted by the National School Boards Association (NSBA) found that parents see the Internet as an important resource for increasing family involvement in schools (NSBA, 2000). In particular, parents reported being very interested in communicating with their children's teachers via the Internet. More than half of all parents surveyed by the NSBA wanted to see their children's schoolwork online and use e-mail to communicate with their local school board.

As more and more schools have become connected to the Internet, commercial education vendors have identified opportunities to develop products that make it easier

---

[3] Some of the activities parents are encouraged to use with their children are designed to accompany the games found on the Lightspan software. At the time of this report, they could be accessed at no cost to parents at the Lightspan Web site.

for teachers and other school officials to create school Web sites designed to make home-school communication more effective and efficient. One company whose products we reviewed, bigchalk.com, hosts a wide array of subscription-based and free resources, including "the bigchalk community," which provides Web site development tools for schools. Although companies have designed templates for developing Web sites for administrators and other staff to post information of interest to the school community, classroom teachers typically are the primary content generators for these sites. At Pine Crest School, for example, teachers are required to use the bigchalk Web-hosting service to present up-to-date information for parents on class activities and assignments. Teachers at Learning Network's "myschoolonline" schools use their sites to post assignments, materials students need, and exemplary student work and awards.

More recently, commercial education providers have begun to approach school districts with products that are aimed at replacing the student information management systems typically run on large mainframe computers at the district office. Some of these products, like Apple's PowerSchool product, are Web based and can be hosted by the commercial provider instead of on a district server. These student information management systems automatically track information and organize data for monitoring, grading, and reporting purposes.

What is unusual about many of the products, compared with traditional student information management systems, is that they include a parent component. Parents can check students' attendance, grades, and assignments on the Internet with their own username and password at any time. The advantage of such a product, companies argue, is that parents do not have to wait until report cards are sent home to learn how their children are performing in school.

Voicemail Programs

Targeted efforts to increase parent communication with schools through technology have been advocated as a strategy to increase parent involvement (Blanchard, 1997; Osher & Snow, 1997). In the past, many of these efforts have relied on face-to-face meetings or sending print materials home to increase parents' at-home involvement in homework, tutoring, or other school-related activities. Today, new technologies are available that make parental involvement easier via the Internet, television and video technology, and even telephones.

Many schools across the United States have developed programs that rely on voicemail technology to improve parent-school communication. The Transparent School Model (Bauch, 1994), for example, uses a voice messaging system in which teachers record a brief message for parents each day describing the day's lessons, special events, homework assignments, or announcements. They can even record messages that are automatically delivered directly to students' homes. Parents can call the system at any time and listen to or record messages for the teacher to hear. Such programs aim not only to increase the *frequency* with which parents and teachers communicate with one another about important matters related to students' education but also the *quality* of that information, by providing timely information that helps parents and teachers coordinate their teaching efforts at school and at home.

In this study, we report on results from one study of a voicemail program conducted in Canada by researchers studying parent-school interaction at the elementary school level. This study was the only one to meet the criteria of reporting on program outcomes that were applied to all relevant studies considered for the research synthesis. To date, there have been no studies of the effectiveness of commercial education products targeting parent-school communication. Because these products are growing in number and popularity, however, we conducted site visits to schools and districts using commerical products to learn more about how they are implemented and to investigate participants' perceptions about their effectiveness.

The Value of a Research Synthesis

Although there have been evaluation studies of some programs designed to use Technology to link home and school, to date there has been no comprehensive review of these studies. Most of these studies do not appear in published journals and can be difficult for decision-makers to find. They are published on the Internet or in conference proceedings, or must be obtained by writing to authors or vendors directly. New evaluation studies become available at a rapid pace, and it is difficult to keep track of these new efforts. Indeed, during the course of our search for studies, three new evaluation studies were published in online conference proceedings in 2001.

In addition, there are no studies in some of the more rapidly growing uses of technologies to link parents more closely with schools. Many of the newer commercial education products have not been evaluated, nor have there been studies of the increasingly popular computer recycling and repair programs. More data on how these programs are implemented could inform future evaluation designs are needed.

Leaders in schools, districts, and state and national departments of education need data on program effectiveness and on issues faced by schools when implementing these kinds of programs to make good decisions about where to invest technology dollars. Researchers need to know what gaps there are in knowledge of programs' effectiveness in order to design future evaluation studies that address these gaps. The U.S. Department of Education contracted SRI International to conduct a review of what is known about the effectiveness of programs that use technology to link home and school more closely and to conduct case studies to identify promising practices in this domain. This report synthesizes findings from the literature review and case studies.

The next section describes the procedures used to conduct this study. It includes a description of the approach to the search for studies, criteria used to determine whether studies were to be included in the synthesis, and data analysis techniques. In addition, the section includes explanations of important terms like "effect size" that are necessary to interpret the reported results. In the subsequent section, results across the studies are presented.

Study Design and Methodology

Overview and Summary of Study Design and Methodology Section

In this section, we describe our approach to the evaluation synthesis. Evaluation syntheses of educational technology, like other evaluation syntheses, rely on a systematic review of other researchers' findings as the basis for drawing conclusions about the effectiveness of particular programs. At the same time, educational technology evaluation syntheses must take into consideration factors unique to the implementation of technology programs in schools. The novelty of a technology, how widely it is disseminated, and when a program's effectiveness was tested are all likely to affect the results of an evaluation synthesis in educational technology.

Our process for identifying articles and studies of relevance for this evaluation synthesis entailed a systematic search for articles and studies, assessment of article relevance, and coding and analysis of the articles and studies identified. Several educational databases were searched for articles, as well as the Internet. Researchers developed criteria for relevance before obtaining and reviewing articles. Articles included in the review had to measure student or parent outcomes and rely on an experimental, quasi-experimental, or pre-post design. Articles published in peer-reviewed journals, dissertations, and reports published by independent organizations or on the Internet were all included in the review. A total of 19 articles are included in the synthesis.

To record common data elements for the evaluation synthesis, SRI entered information from the studies into a database. This database included fields for researchers to enter data that are typically included as part of any research synthesis: bibliographic and location information, the focus of the study, the study design, measures used, results, and study authors' own interpretations and conclusions from the study. All coders were trained in the use of the database, using a subset of articles as anchors coded by two different readers. A single researcher coded the other articles, and the first author of this report reviewed the codes for all articles.

For 13 of the 19 studies included in the review, SRI researchers calculated *effect sizes* for all sub-analyses conducted by other researchers and evaluators. An effect size is a measure of the magnitude of the effectiveness of a program; it permits researchers to compare results across multiple studies by converting findings to a common metric. The metric for effect sizes takes into account differences between the means of treatment and comparison groups and sources of error or variation across groups, where possible controlling for prior achievement and initial differences between treatment and comparison groups. For this research synthesis, a total of 103 effect sizes were calculated from all sub-studies. These effect sizes are included in this report, in tables either within the body of the report or in the appendices.

As part of the evaluation synthesis, SRI researchers also conducted case studies of eight programs designed to link home and school through new technologies. These case studies were designed to provide information on new and emerging programs that are intended to link home and school more closely and are becoming popular, even though their effectiveness is not yet known. They also were intended to identify challenges and strategies for implementing, scaling, and replicating programs that research has identified as effective in improving student achievement, increasing parent involvement in the learning process, or improving parent-school communication. For all programs that were part of the case study research, we focused on understanding better how program stakeholders and participants interpret key program features, rather than on independent results from evaluation studies.

Issues in the Synthesis of Educational Technology Research

This report is organized around findings from an evaluation synthesis. An evaluation synthesis is a systematic examination of findings from a number of studies that have investigated a phenomenon of interest to researchers or policy-makers (U.S. General Accounting Office, 1992). An evaluation synthesis assumes that prior studies are the basis for building a clearer understanding of the effectiveness of particular aspects of programs or interventions (Cordray & Fischer, 1994). On the one hand, this assumption permits researchers to provide a comprehensive review of what is known in an area at a relatively inexpensive cost. On the other hand, evaluation syntheses are limited, in that their quality is dependent on the quality of prior studies in a particular domain. This particular research synthesis shares in the strengths and limitations of other syntheses: it provides an accessible summary of findings of program effectiveness from a range of studies, but a number of the studies considered in the review have methodological limitations that prevent one drawing conclusions from their results about whether participation in programs caused or explain specific outcomes.

Another important consideration in any research synthesis of studies related to technology pertains to the time at which the studies were conducted. Educational technologies have developed rapidly over the past 20 years, and uses of technology in schools and at home have undergone several transformations as multimedia authoring tools, the Internet, and visualization and modeling software have all become more widely available (Valdez, Foertsch, Anderson, Hawkes, & Raack, 2000). Programs' effectiveness depends critically on the diffusion or spread of an innovation or program throughout the system it is intended to affect. The diffusion of an innovation, in turn, depends on a range of factors, including its perceived benefits, its compatibility with the existing values and goals of the educational system, and how well understood the innovation is by potential adopters (Rogers, 1995). For nearly all the interventions in this study, results are reported not at what might be considered "late" stages of innovation diffusion but rather at "early" stages of innovation diffusion. For this reason, we might expect results to be different for evaluation studies that measure the impact of technology innovations once they themselves have matured and saturated the educational system.

This particular evaluation synthesis goes beyond traditional narrative reviews of research in its use of a systematic procedure for locating, interpreting, and recording results from prior evaluation studies. Traditional narrative reviews of research, although valuable in areas where little research has been conducted, are often biased by researchers' own interests in the study and by unprincipled selective examination of study findings (Light & Pillemer, 1984). Contemporary methods in research synthesis, such as meta-analysis (Glass, McGraw, & Smith, 1981; Hedges & Olkin, 1985) and best-evidence approaches to synthesis (Slavin, 1986), allow researchers to compare results across studies much more systematically, the basis of clear criteria for inclusion of studies and reliable coding and analysis of study findings. This synthesis reports both effect sizes calculated from particular studies and on narrative accounts of quasi-experimental studies for which statistical information needed to calculate an effect size could not be identified.

Case studies are sometimes used in evaluation syntheses to provide information about programs that cannot be found in research studies and to supplement data found in research studies with descriptions of comparable phenomena that original researchers may not have examined. We selected the sites for our case studies to address two issues. First, educational technologies evolve rapidly and are widely adopted on the basis of on their promise to transform teaching and learning, even before programs' effectiveness can be demonstrated (Cuban, 1986, 2001). Therefore, our case studies provide information on new and emerging programs intended to link home and school more closely. Second, policy-makers and evaluators need clues about how to evaluate such programs, as well as what issues schools face when implementing them. Therefore, we also have conducted case studies in sites where there is some evidence of program effectiveness, based on research findings found in our review, in order to identify in this report the implementation issues, as well as issues related to replicability and scalability of programs.

In this section of the report, we describe the criteria for inclusion of studies in the research synthesis, specific search procedures used to identify evaluation studies, the process used for coding (reading, interpreting, and recording) results, our case study methodology, and the approach we used to analyze and synthesize findings from the evaluation studies and our own case studies.

Procedures Used to Identify Evaluation Studies

Our primary goal in conducting the search for evaluation studies was to identify all studies of programs that used technology to support better links between home and school. Our search encompassed both published and nonpublished studies, because publication bias tends to increase the likelihood of finding significant effects of a program (Dickersin, Min, & Meinert, 1992) and because many reports on technology in education are published on the Internet, rather than in peer-reviewed journals. Before obtaining documents for the review, we conducted initial and secondary searches designed to find documents that are likely to address student learning, parent involvement, or parent-school communication outcomes, or provide detailed information on the actual implementation of programs. We obtained those that met the search criteria, and from among the studies obtained, we selected for analysis those evaluation reports and articles that met the criteria described below for substantive and methodological relevance to the review.

Initial Search for Studies

To conduct the initial search for documents, SRI researchers began by identifying keywords that were likely to yield appropriate articles and studies. We used keyword searches with both databases of academic research (e.g., ERIC) and a search engine (Google) on the Internet to identify any articles published or made available through other means from 1995 to 2000 (see Figure 1). We focused primarily on terms that were directly related to the topic of the review, but we also knew from our preliminary research on the topic that laptop and voicemail programs had been studied, so we conducted a search using these terms, as well.

Figure 1
Search Terms for Educational Databases

home AND technology
home AND school AND technology

home AND computer
home AND school AND computer

parent AND technology
parent AND computer

family AND technology
family AND computer

laptop
voicemail OR voice mail

Table 1 shows the results of our initial search, which yielded 98 documents that were then reviewed for more specific relevance to the study.

Table 1. Databases Searched for Review

Database/Source	Hits	Abstracts Reviewed for Relevance
Education Research Databases (ERIC, Resources in Education, Current Index to Journals in Education)	7271	41
Dissertation Abstracts	2030	12
Educational Research Abstracts	122	9
Review of Journals (1995-2000):		
Educational Technology	274	0
School Community Journal	61	0
IT in the Home Database	287	10
CILT Knowledge Network	0	0
Google (Internet)	Millions	26
TOTALS	Millions	98

As Table 1 suggests, there were a large number of hits relative to the number of articles judged to be relevant to the review. The reason is that the keyword search terms are very broad to avoid missing any relevant articles. In each case, the researcher conducting a review of the initial search returns had to apply basic criteria of topical relevance, thus reducing the number of possible articles reviewed. In the case of Web searches using Google, the first 100 hits were each reviewed before determining whether they should be considered for possible inclusion in the review. Documents that were farther down the list of returns were spot-checked to ensure that using the first 100 hits did not introduce any systematic bias into the Web search procedure.

Additional reports and articles were sought by contacting a sample of national, regional, state, and local educational organizations that focus on technology in learning. A customized letter was sent to each organization stating the purpose of the request, the context of the study, and the specific types of documents requested (should they exist). Appendix A shows the list of organizations that were contacted and the specific types of information requested from each one. Within 4 weeks of sending out the letters, an SRI researcher made a follow-up call to each organization that had not yet replied to the request to determine whether the organization had any relevant studies, reports, or research articles related to the topic of enhancing home-school connections with technology. Letters and calls to these organizations resulted in the location of two additional evaluation studies conducted by researchers in Delaware studying a U.S. Department of Education Technology Innovation Challenge Grant.

We also conducted a second Web search of information from specific companies that are known to have developed products aimed at parents or at teachers seeking to enhance communication with parents. The list of companies that have developed such products was selected from the list of vendors and products outlined in the Education Commission of the States' (2000) report *Smart Desktops for Teachers.* Although this list was not intended to be a comprehensive listing of all commercial products aimed at fostering better home-school connections with technology, it is one of the most complete listings of such products by an independent, third-party group of researchers. In this search, we sought additional information on the use and impact of these products as reported in unpublished or published studies. We discovered the existence of six evaluation studies documenting the effectiveness of the Lightspan *Achieve Now* software in schools from this search.

A researcher recorded basic information about each study from the initial search. At this early stage, a broad set of criteria was used to determine relevance of the study. If the study appeared to address the topic of computers at home and it addressed student achievement, parent-school communication, or parent involvement, then it was marked as relevant. For each of these articles, basic information about the study, including the study abstract, was entered into a FileMaker Pro database.

Assessing the Likely Relevance of Studies

The first author of this report reviewed the database after all relevant educational research databases were searched. The abstracts of articles were used to determine whether the study in fact was likely to have any data about outcomes or whether it might provide specific implementation-related data that would be helpful to policy-makers or educators seeking to design an effective intervention. Figure 2 shows the more detailed relevance criteria the first author used to determine relevance. To be considered for possible inclusion in the review, the study had to report either on outcomes or on implementation. If it appeared to be a study of program implementation, to be considered valuable for the purposes of this synthesis, the study had to do more than describe the program in its ideal form or as designed. The study abstract had to state that data from program implementation were considered in order for the study to be included in this review.

Figure 2
Secondary Relevance Criteria for Search

Is the study likely to report data on outcomes?
Student engagement
Student achievement or learning
Parent-school communication
Parent engagement in student learning

Is the study likely to have details about how a program was implemented?
Supports and barriers to implementation
Technical requirements/access patterns
Amount of technology use

If the study is an implementation study, does it appear to be a description of the program in the ideal (e.g., focused on program features) or does it describe actual patterns of program implementation?

This initial search for documents and determination of relevance produced a total of 28 studies with quasi-experimental or experimental designs and 7 implementation studies that were published from 1995 to 2000. Many documents were excluded from consideration were that they were primarily descriptions of program designs, reviews of multiple program designs, or theoretical or opinion pieces about the purported value of specific programs. A large number of articles would best be described as "journalistic." This critique is sometimes leveled at qualitative research, but these articles did not meet the standard of most qualitative research that similar data be collected and reported systematically from a broad array of program stakeholders (Marshall & Rossman, 1995). Although articles describing the designs of programs in the ideal are of some value to decision-makers, we limited the focus of this review to studies that reported actual implementation data.

Secondary Search for Documents

Because of the rapid growth in programs (especially laptop programs) over the past year, it was important to use other means to identify studies that had recently been completed or were under way and might be completed in time for possible inclusion in the review. We used four strategies to identify additional studies.

First, we conducted an ERIC search by author for any researchers who were cited by three or more different studies to determine whether any studies that were relevant to the review might have been missed by the initial search. The secondary relevance criteria (Figure 2) were used to determine whether to collect additional articles for inclusion in the database of studies. This search strategy did not yield any new articles.

Second, we contacted the original researchers to determine the status of their most recent research on programs. In some cases, evaluation studies of programs were ongoing, while others had been complete for 1 to 2 years. At least one researcher we contacted referred us back to the vendor that sponsored the study for further questions. From contacting original researchers, we learned of one new study that researchers said would be complete in time for possible inclusion in this synthesis. Researchers received a complete evaluation report from that study in June 2001.

Third, we examined two major education and technology conference schedules in spring 2001 for current research that might have been recently completed. Though this is an unusual step in a research review, because we found so few studies in our initial search that met the basic criteria of relevance and because the field of practice is advancing so rapidly, we believed it would be valuable to undertake such a search. We found one study presenting results from a laptop program at the Annual Meeting of the American Educational Research Association (it was not ultimately included in the review because it did not meet the criteria for inclusion) and two quasi-experimental evaluations of laptop programs at the National Educational Computing Conference in Chicago, which featured a strand for laptop program workshops and research papers.

Finally, to reduce bias that might have been caused by selective identification of new research, we completed a new ERIC search in June 2001 using each of the search terms in Figure 1. The search yielded 18 hits, but none of the studies met even the initial relevance requirements for inclusion in the study. Time limitations did not permit us to repeat the Web search in summer 2001.

Determining Criteria for Inclusion of Studies in the Evaluation Synthesis

This research synthesis is unusual both in its examination of extant studies in the field and its reliance on primary data collected as part of the review of research. The synthesis includes both articles that provide quantitative data about programs' effectiveness and studies with qualitative data on program implementation. (Some studies include both quantitative and qualitative data on program implementation.) Data from the qualitative studies are woven into the sections of this report dedicated to program implementation challenges and scaling and replicability.

The quantitative dimensions of this research synthesis are based on effectiveness studies of programs that use technology to link home and school more closely. To be included in the synthesis, studies needed to have *topical relevance* to the review (Cordray & Fisher, 1994). The study had to report on one of three outcomes: (1) increased student achievement, (2) increased parent involvement in their children's learning, or (3) improved parent-school communication. Topical relevance was identified after the initial search for documents and used in the process described above to select articles for possible inclusion in the synthesis.

There also were requirements for *methodological adequacy* for the studies to be included in the outcomes section of the synthesis. Though not all studies had to be free of all threats to validity (Cook & Campbell, 1979), they had to meet the criterion of being either quasi-experimental or experimental in design. Studies had to use comparison groups, either by comparing results between a treatment and comparison group or by using a pre-post single-group design to measure change over time for the treatment group. This requirement, at least initially, resulted in a decision to include a study quasi-experimental, or experimental even if specific numeric findings were missing from the report. Because global ratings of a study's methodological quality can be unreliable (Stock et al., 1982), we did not rate overall methodological quality. However, because issues of methodological adequacy emerged as central problems in the review, specific methodological issues across studies are examined in greater detail in the Key Findings section of this report.

Relying primarily on quasi-experimental and experimental studies has both advantages and limitations for the research synthesis. On the one hand, both kinds of design provide better evidence that a particular program is having a desired effect on the treatment group. At the same time, some studies might be excluded that contribute to converging evidence about program effectiveness, if the studies rely, for example, on one-time surveys of program participants at the end of the evaluation study. In addition, even if studies are quasi-experimental, if one or more methodological threats to validity are common to all the studies included in the review, researchers may conclude that congruent findings indicate a real effect, when none is present (Jackson, 1980; cf., Wortman, 1994).

Of the 28 outcome studies identified from the primary and secondary searches for studies for the research synthesis, 9 studies were excluded from the synthesis for methodological reasons. On the basis of an initial reading of these studies by SRI researchers, although the abstract of study described findings in terms of impacts on student learning or on parent communication, they failed to meet the criterion of being either quasi-experimental or experimental. One study relied on a single-group, posttest only survey design to measure program effectiveness. Another provided selected interviews with program participants and reported no outcome data at all. These studies became part of the implementation case study sample for later qualitative analysis. Six studies were excluded because they did not have well-defined comparison groups. Three of these studies examined achievement at only one point in time and used school district achievement levels for comparisons to the treatment.

Coding and Analysis of Evaluation Studies

To record common data elements for the evaluation synthesis, the U.S. Department of Education instructed SRI to use a database, the Research Article Profile System (RAPS), developed by the American Institutes for Research as part of a separate task. This database included fields for researchers to enter data that are typically included as part of any research synthesis: bibliographic and location information, the focus of the study, the study design, measures used, results, and study authors' own interpretations and conclusions from the study.

To prepare coders for the task of coding articles, a draft coding guide was developed by the first author and a second SRI researcher working on a related research synthesis for the U.S. Department of Education. The second researcher's research synthesis was intended to be methodologically consistent with the current review and included several articles that are also considered in this synthesis. This guide was based on an initial reading of a sample of 10 articles obtained and considered likely candidates for inclusion in the final review. Missing data or likely sources of confusion for coders were identified, and decision rules for coding articles were developed before coders were trained.

Coders received training in three separate "anchoring" sessions designed to establish reliability among coders for entering data into the RAPS database. These sessions served both as a pilot test of the coding protocol (Stock, 1994) and as a step toward ensuring reliability among raters of articles. These anchoring sessions were run in a way similar to the ways that "anchor" papers or work samples are used to ground assessments of student work. Each coder was first given an advance organizer (Appendix B) as a guide in the reading process. Using the organizer and the draft coding guide, two pairs of coders read five research articles independently from one another and then in pairs discussed how they would enter the data into the RAPS database. Pairs worked on coding single data elements across all five studies and then discussed each element as a small group together, developing decision rules for coding ambiguous elements in the database. This paired-coding method was used for all "critical fields" in RAPS, that is, data elements that were identified at the outset of the research synthesis as of central importance to interpreting findings of the review or as likely or potential threats to the validity of the studies (see Appendix C for the coding guide). Using research papers as anchors can be useful tools for establishing reliability among raters, especially when raters work in pairs or groups (see Aschbacher, 1999, for an example of using anchors to augment reliability of assessments of student work in classrooms).

The four researchers trained in the use of the coding guide then completed the coding of all information for the remaining studies to be included in RAPS. The first author, who was not a coder for the articles, conducted an independent reading of all the articles read by the coders and checked the RAPS database for completeness and consistency of reporting. Each entry was compared against a 1 to 2 page narrative summary of the research findings developed by us to ensure that multiple interpretations of findings were included in the RAPS database in fields designated for coders' notes and interpretations.

The goals of the present study dictated that the effect size be calculated for multiple analyses within a single study, but a mechanism other than the RAPS database was needed for the calculation. Because the RAPS database design is itself complex, collecting these data would potentially distract coders from paying close attention to the content of their entries. Therefore, in articles or reports with sub-analyses, coders were instructed to code only one of the analyses within each report or article, and to choose the analysis with the largest combined *N* for treatment and comparison groups for inclusion in RAPS. To gather additional data from sub-studies and sub-analyses, the first author developed a table for collecting data needed to calculate an effect size for all studies: numbers of study participants, means, and standard deviations, for treatment groups and comparison groups. For this research synthesis, a total of 103 effect sizes were calculated from sub-studies.

Effect sizes allow researchers to compare results across multiple studies by converting findings to a common metric that takes into account differences between the means of treatment and comparison groups and sources of error or variation across groups (Hedges & Olkin, 1985; also see Inbox).

What is an effect size?

Often, policy-makers want to know an answer to the question "What does the research say about the effectiveness of programs that *do X*?" If there are several studies of these kinds of programs, there are likely to be conflicting findings. These findings arise because researchers use different designs, outcome measures, sample sizes, and other factors. One researcher may conclude from a study that a program is not effective, while another concludes that it is. Most researchers, moreover, don't tell us how big or how small the effects are. Instead, they use statistics to determine a simple "yes" or "no" answer as to whether a program is effective.

To compare results across studies of a particular type of program, different information is needed. First, we need to know how large or small the effects are for each study and whether the effects are positive or negative. Second, we need a common metric for comparing results from studies that may have used different outcome measures. Researchers have developed a metric called *effect size* for comparing results across studies that allows one to calculate the magnitude of a relationship between an intervention (e.g., a laptop program) and an outcome (e.g., student test scores).

Typically, effect sizes are calculated for studies in which students from an intervention group and from a matched comparison group have been tested with the same measure of performance. The first step in calculating effect size is to calculate the difference between the average scores of students in the treatment or intervention group and the average scores of students in the comparison group. This result will determine whether the effect size is positive or negative. A positive score means the students who received the intervention outscored the students in the comparison group. The second step is to divide the difference in average scores by some measure of the variation in scores in the groups. Usually, the standard deviation of the comparison group is used as the denominator. One could say, then, that the effect size is the proportion of the standard deviation by which a treatment group outperforms a comparison group.

To illustrate, say a researcher found that students in a laptop program score, on average, 50 points on a test of their technology proficiency and students in a comparison group score 40 points on this test. The first part of measuring the effect of the laptop program would be to subtract the comparison group mean from the laptop group mean. The 10-point difference would be the "effect" of the laptop program, if there were no variation in scores within each group. Alternatively, one could say that laptop students scored 25% higher than comparison group students on the test.

Not all students are likely to earn the same score on the test, however. Some students in the laptop group might have scored less than 50 points, for example, and some students in the comparison group might have scored 50 points or higher. The effect of an intervention thus depends also on controlling for a measure of the *variation* in student scores, usually the standard deviation of the comparison group. If the standard deviation of the comparison group were 40 points, to calculate the effect size for this study, we would take the difference in mean scores (10 points) and divide it by the standard deviation (40 points). The effect size of this study would then be +0.25.

To understand the practical meaning of an effect size, it is important to know how an effect size compares with more familiar metrics or with results from other interventions. For example, an effect size of +1.0 is equivalent to about 15 points on an IQ test or 21 NCEs on the Stanford Achievement Test. Sometimes, effect sizes are reported in terms of "months of learning gain" or "grade equivalents." Effect sizes of educational interventions are rarely as large as –1.0 or +1.0. For example, many educators believe that reducing class-size is an effective way to improve student learning, but effect sizes for studies of class size reduction are between +0.13 and +0.18. Interpreting effect sizes requires caution: "small" numerical effects may be "large" in terms of their practical significance, depending on the field of study.

We calculated effect size by using Cohen's *d*. Effect size as calculated by Cohen's *d* is the mean of the treatment group minus the mean of the comparison group, divided by the pooled standard deviation of the two groups (Cohen, 1988). Cohen's *d* was chosen because the statistic matched well the designs of the studies found in the review and because one can convert effect sizes from the *r*-family (effect sizes that correspond to accumulations of correlations found between treatment and outcome variables) easily to Cohen's *d* (see Table 2 for a summary of how effect sizes were converted for each study).

Table 2. Methods for Computing Effect Size, by Study

Study	**Method for Calculating Cohen's *d***
Lowther, Ross, & Morrison (2001)	From results of *F* test
Myers (1996)	$(M_{treatment} - M_{comp})$ / pooled SD
Schaumburg (2001)	From results of *F* test
Schieber (1999)	$(M_{treatment} - M_{comp})$ / pooled SD
Stevenson (1998)	$(M_{treatment} - M_{comp})$ / pooled SD
Haynes (1996)	$(M_{treatment} - M_{comp})$ / pooled SD
Siegle & Foster (2000)	from results of *t* test
Light, McDermott, & Honey (2001)	$(M_{treatment} - M_{comp})$ / pooled SD
Chang et al. (1998)	From results of *t* test
Gwaltney (1998)	$(M_{treatment} - M_{comp})$ / pooled SD
Gwaltney (1999)	$(M_{treatment} - M_{comp})$ / pooled SD
Gwaltney (2000)	$(M_{treatment} - M_{comp})$ / pooled SD
Cameron & Lee (1997)	From BESD

Most studies in the review were two-group designs, where researchers compared two means by using a *t*-test. When pre-test data were available, effect sizes were adjusted to control for prior achievement by calculating an effect size from pre-test data and subtracting it from the effect size of the post-test calculated effect size. Some studies did not report data needed to calculate Cohen's *d* from means and standard deviations: the statistic had to be calculated from results of a *t*-test or an *F*-test instead. For one study, Cohen's *d* was calculated from a Binomial Effect Size Display (Rosenthal, 1994). When data were missing that were needed to calculate Cohen's *d* directly, an SRI researcher attempted to contact the researcher(s) to request the data. An SRI researcher made follow-up telephone calls or sent e-mail to 11 researchers in search of these data.

When studies provided both pre- and post-intervention mean scores and standard deviations for the treatment and control groups, we calculated the overall effect size by taking the difference between the gains in achievement for the treatment and comparison group. We did this by first calculating the effect size for the gain in the outcome indicator separately for each group by taking the difference between the pre-test and post-test means and dividing by the pooled standard deviation using the group's pre- and post-intervention standard deviations. Thus for those studies where it was possible to calculate the gains in achievement for each group, the overall effect size reported for those studies represents the difference in the effect sizes of the gains for the treatment and comparison groups. The use of the differences in gains for the calculation of effect size is consistent with earlier meta-analytic procedures used by Kulik and Kulik (1991).

Researchers differ in their approach to aggregating the results of calculating effect size (see Light & Pillemer, 1984). Many evaluation studies or reports include multiple analyses, and several different effect sizes can be calculated for each one. Others, however, contain just a single study. One approach researchers have used to aggregate findings is the "one study, one vote" approach.[4] Rosenthal (1994) argues that this method is a conservative but inaccurate way to combine effect sizes within a single study. Moreover, important differences in effects can emerge when data are disaggregated along lines that other educational research has identified as significant, such as grade level, achievement level, or socioeconomic status (see Camilli & Bulkley, 2001).

We decided to use a combination approach to examining effect sizes across studies, an approach recommended by Light and Pillemer (1984). First, we calculated all effect sizes, uncorrected for variations in sample sizes, for all sub-studies that document effects for the five main outcomes measured: reading achievement, mathematics achievement, writing achievement, other student outcomes, and parent involvement. In many cases, single studies appear more than once, if more than one subanalysis was performed by the

[4] This procedure should not be confused with the "vote counting" approach to research synthesis, in which overall results of a study are counted as "positive," "negative," or "no difference," and then the total number of studies in each category is used to aggregate findings.

researcher. Although some sub-studies tested the same subjects on multiple indicators, in more than half the sub-studies, researchers had disaggregated their data reports by grade level, so we decided to report all sub-studies for each type of outcome. Each of the results of these effect size calculations appears in a separate appendix to this report (Appendices E-M). We also used a variation of a "one study, one vote" approach. We used an average effect size for each desired outcome of home-school links programs (student achievement, parent-school communication, parent involvement), using the average effect size for all analyses within a single report as the basis for computing an overall average effect size for all programs in our study.

These results should be interpreted with caution, since grade-level effects can be found within individual studies (see Light & Pillemer, 1984); therefore, in the narrative of the text, we have outlined where these effects are present. We also disaggregated results across studies to examine more closely specific effects of programs on low-performing and low-income students. These groups of students are often the focus of laptop programs and reading programs; knowing how they perform relative to other low-performing or low-income students can provide insight as to the relative effectiveness of programs for these groups.

Interpreting effect sizes is not a straightforward matter. The significance of an effect size depends largely on the type of program and desired results (Glass et al, 1981). Although some researchers (e.g., Cohen, 1988) have offered heuristics for judging effects to be "small," "medium," or "large" based on effect size, the practical significance of effect size is likely to vary by discipline or from program to program (Lipsey, 1990). Qualitative data in this case may inform the quantitative analyses by providing additional data about how program participants perceive the relative success of the programs in the domain of technology supports for linking home and school more closely.

In this research synthesis, reported effect sizes must be interpreted in light of the adequacy of the research designs used in particular studies to test causal links between participation in programs and outcomes measured. Just 2 studies included in this review used random assignment to treatment and comparison groups, and many studies were of programs that were implemented in schools and districts where other reforms were being implemented. We report effect sizes here primarily as guideposts to future research. We believe that the effect sizes reported here, which are comparable to those found for many other educational interventions, bear further investigation in rigorously-designed studies. At the same time, effect sizes reported in this synthesis that are typically interpreted as non-significant in other meta-analytic studies should not be interpreted as evidence that programs are having little or no effect on students or parents. These programs' effectiveness could also be investigated in future evaluation studies.

Case Study Methods and Analysis of Qualitative Studies

As part of this evaluation synthesis, we conducted case studies of eight programs designed to link home and school through new technologies. The purpose of these case studies was twofold: (1) to provide information on new and emerging programs intended to link home and school more closely that are becoming popular, even though their effectiveness is not yet known, and (2) to identify challenges and strategies for implementing, scaling, and replicating programs that research has identified as effective in improving student achievement, increasing parent involvement in the learning process, or improving parent-school communication. For all programs that were part of the case study research, we focused on understanding better how program stakeholders and participants interpret key program features, rather than on independent results from evaluation studies. Visits were made to programs either identified as promising or documented in independent evaluation research as exemplars of best practice.

Candidates for site visits were identified from our preliminary review of research and from published lists of major commercial education providers and their products found in the Education Commission of the States' (2000) report *Smart Desktops for Teachers*. Our goal was to find three case study sites that reflected a broad range of technology uses and that focused on each of the three major goals that technology-supported home-school linkage programs typically hold: (1) increasing student engagement in learning, (2) enhancing parent-school communication, and (3) increasing parent involvement in the learning process. We also attempted to create a sample of sites that includes a mix of urban, suburban, and rural programs, as well as programs targeted specifically to low-income parents and to parents of English language learners. SRI researchers initially identified a list of 30 possible sites and developed short descriptions of these sites for possible inclusion in the case studies. SRI worked closely with ED to develop a final list of nine case study sites willing to participate in the study (Figure 3).

Figure 3. Case Study Sites

Laptop Programs

Learning with Laptops, Beaufort, SC. A Microsoft-Toshiba Anywhere Anytime Learning program started in 1995 for students in three middle schools aimed at helping increase equity and achievement.

District 6 Laptop Project, New York, NY. A Microsoft-Toshiba Anywhere Anytime Learning program targeting 5,000 elementary and middle school students in this inner-city district of 30,000. Goals include providing technology access for students, professional development for staff, and training opportunities for parents, and use of technology to promote higher-order thinking.

Home Desktop Programs

Computers for Youth (CFY), New York, NY. Provides inner-city middle school students and their teachers with fully equipped home computers and comprehensive services, including training, technical support, and tailored Web content. Founded in 1999 to serve the neediest schools in New York City, CFY has distributed 700 computers in four communities and plans to distribute 1,200 to 2,000 desktops per year starting in 2001.

The Buddy System Project, Indiana (statewide). The project was founded in 1988 to use digital technology to increase equity among students, extend learning beyond the school day, and provide adults opportunities to be involved in their children's learning as well as to gain workplace skills.

Telementoring Programs

Education Program for Gifted Youth (EPGY), Stanford, CA. Since 1989, the project has been providing online instruction to gifted youth in a broad range of subject areas. EPGY has both home-based and school-based programs that focus on meeting needs unmet in students' schooling. The basic software is supplemented by virtual classroom sessions, e-mail, and some telephonic contact with instructors.

Commercial Education Products Targeting Home-School Communications

bigchalk.com. bigchalk provides a wide array of subscription-based and free resources, which are used by more than 40,000 schools. The free resources include the bigchalk community, which provides Web site development tools for schools. We conducted a site visit with a new bigchalk community member, the Pine Crest School, whose Web site was featured as bigchalk's spotlight site at the end of the 2000-01 academic year.

Learning Network's Myschoolonline. myschoolonline has a Web site development service that is a key feature of the Learning Network's products. We spoke with teachers who use myschoolonline tools at three schools in California.

Homeworkhelp.com. In 2000, Homeworkhelp launched its "MySchool" product, which features an integrated online system to support communication among parents, teachers, and students about homework assignments, grades, and upcoming school news. We spoke with company officials and a district technology coordinator in California.

Discrete Educational Software for School and Home Use

Lightspan's Achieve Now. This Lightspan product includes animated games that support skill-building in reading, writing, and mathematics. Schools often send Lightspan CDs home with assignments for students to use the software with their parents. We visited Idaho's Blackfoot District 55, where Lightspan software was originally purchased as part of an ED-funded Community Technology Centers grant.

For all the sites, researchers used structured interview protocols to interview key program stakeholders and participants (see Appendix D for protocols). Researchers responsible for a particular program completed a debriefing form designed to collect common data elements for program goals and objectives, benchmarks or milestones used by the program to measure success, staffing and professional development, use of technology by participants, implementation barriers and supports, and outcome data (where available). Because finalization of the case study sites took much longer than expected, SRI was not able to begin site visits until April 2001. In six cases, we were able to visit sites for 1 to 2 days and talk with program directors, teachers, parents, and students. In two cases, we were able to conduct interviews only by telephone or were unable to speak with representatives of some stakeholder groups (e.g., parents).

From the debriefing forms, we developed a case study memorandum that focused on cross-case themes and differences. The memorandum organized findings by key program goal (improving student achievement, improving parent involvement in the learning process, or increasing parent-school communication). Each section described program goals, implementation strategies, implementation supports, perceived outcomes, and issues related to sustainability, replicability, and scalability of programs.

We then identified data elements from the case study debriefing form to be included as part of the qualitative section of this report, and focused especially on implementation issues and information about the sustainability, replicability, and scalability of programs. In some cases, studies with outcome data also had information on program implementation, so qualitative findings from these studies were incorporated into the Key Findings section of the report. We then selected three case study sites to feature in greater detail, because they were representative of the issues that surfaced in the site visits. Each case presentation in the key Findings section of this report describes not only the goals and particulars of program design but also how each program addressed implementation and sustainability challenges identified as common to three or more sites we visited.

Key Findings

Overview and Summary of Key Findings Section

In this section, we describe the key findings of the evaluation synthesis, focusing on four main areas:

1. Coverage of the domain and methodological issues.
2. Reading, mathematics, writing, and other outcomes.
3. Parent outcomes.
4. Issues of program implementation.

Most of the studies included in the synthesis were of three types of programs: laptop programs, programs using discrete educational software for use at home and at school, and desktop programs. Although the studies reported results across grade levels from elementary through high school, most of the laptop and desktop program evaluations took place in middle schools, and all the evaluations of discrete educational software took place in elementary schools. Some key program designs for linking home and school have yet to be researched. For example, we found no studies of computer recycling and repair programs, which are increasingly being implemented in high schools. In addition, we found no studies of the new Web-hosting services or student information systems that make communicating with parents about student progress easier. Since these programs are relatively new types, it is likely that studies have not yet been designed to measure their effectiveness.

The research base from which we drew was relatively small, because there have been few outcome studies that have examined these programs' effectiveness. The research designs employed in most of these studies that are included in the synthesis, moreover, make it difficult to draw conclusions about whether providing technology access to students through desktop or laptop programs causes increases in student achievement or using existing technology access to promote greater parent involvement causes improvements in parent-school communication. Just 2 of the 19 outcome studies included in the review relied on experimental designs. Of the remaining quasi-experimental studies included, 10 attempted to ensure that treatment and comparison groups were similar at the outset of the study, and 7 studies did not match treatment and comparison groups at all.

Not all of the sample of studies that met even the basic criterion of being quasi-experimental or experimental provided data that would make it possible for researchers to aggregate their findings into a quantitative research synthesis. About two-thirds of the studies reported the data needed to calculate effect sizes. Nearly all of the 13 studies included attempted to match groups to ensure that the students in the programs were similar in important respects (e.g., prior achievement, family socioeconomic status) to students in the comparison groups. These studies relied mostly on norm-referenced standardized tests, district-level tests, and tests developed specifically to measure the effects of the program being studied.

This report attempts to synthesize the best evidence (Slavin, 1986) available from the research conducted, taking into account the methodological limitations of the knowledge base of studies included in the review. Across the studies that met the methodological criteria for inclusion in the review and reported data needed to calculate effect sizes, there was evidence that program participation and student and parent outcomes were linked in ways that bear further investigation in new, rigorously designed studies. In particular, the mean reported positive effects of programs on students' writing skills are similar in magnitude to other educational interventions, such as the reported effects of computer-assisted instruction on achievement. Mean positive effects on mathematics achievement and parent-school communication are similar to reported effects of reducing class size from 24 to 15 students. However, an equal number of programs that measured these outcomes reported no effect as reported positive effects. The associations between laptop program participation and higher levels of technology proficiency are even higher. Each of these reported effects is suggestive of the potential of programs that use technology to link and school, but the failure of many studies to account for prior differences in student achievement between treatment and comparison groups, few experimental designs, and lack of information on implementation make it impossible to attribute with any certainty the improved outcomes to the use of technology per se.

Researchers reported the largest effects for programs that were part of larger reform efforts aimed at improving student learning. In these programs, technology's role is to support or augment initiatives aimed at increasing expectations for all students, transforming teaching practices, or developing students' literacy levels. In each of these cases, providing or enhancing home computer access was one of many strategies employed by schools or districts to improve schools. Evaluation results from these studies suggest that, although it may not be easy to determine whether greater access to technology at home by itself makes a difference, enhanced home access may work in combination with reform efforts to improve learning outcomes for students.

All of the effect sizes reported in this section should be interpreted with great caution. Because of the methodological limitations of the particular studies that are included in the review, the effect sizes are best understood as measures of association between program participation and particular student or parent outcomes that could be investigated more systematically in future research. In this field, there is a need for rigorously-designed studies, including both experimental studies and those designed to test the effectiveness of particular implementation models, to understand better the likely impact of programs designed to use technology to link home and school.

In this section, we also discuss in greater detail themes from case studies of selected programs that illustrate how three types of programs are typically implemented. We discuss a cross-curricular laptop program, discrete educational software with a home component, and a commercial education product targeting home-school communications. We discuss how teachers understand the goals of the program, how technology is used and supported in each program, how teachers and parents are prepared within each program to participate, and issues related to sustainability.

Coverage of the Domain and Methodological Issues

Focus of Studies

The majority of the studies that examined the outcomes of programs that are considered in of the research synthesis are effectiveness studies of laptop programs (see Table 3).

Table 3. Number of Studies, by Program Type

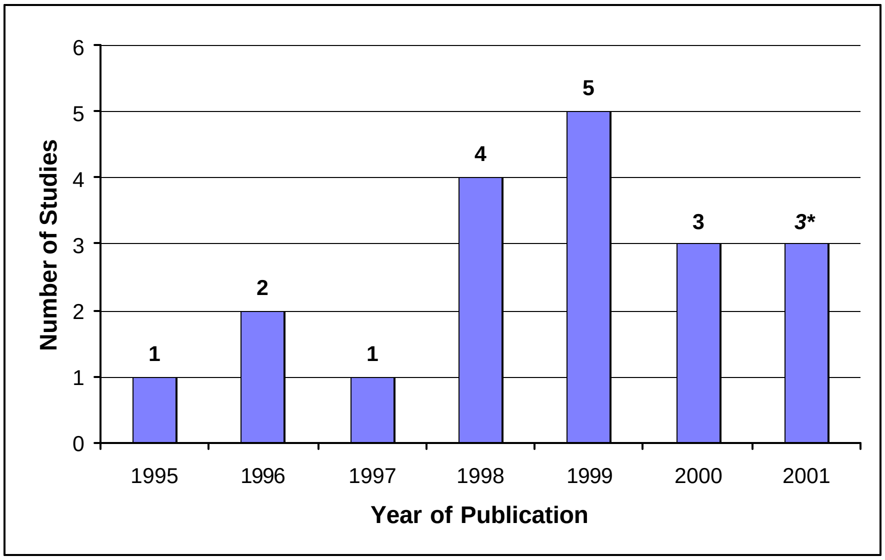
Program Type	No. of Studies	No. of Programs
Laptop programs	12	10
Home desktop programs	2	2
Discrete educational software programs	4	2
Voicemail programs	1	1

Of the laptop programs, there are 12 studies of the effectiveness of 10 different programs. Nine of these studies are of cross-curricular laptop programs, that is, laptop programs that encourage teachers to integrate the use of laptops throughout the curriculum. At least three of these cross-curricular programs are part of the Microsoft-Toshiba Anytime Anywhere Learning (AAL) program, and one set of studies (Rockman et al, 1998, 2000) is an evaluation of the overall AAL program. Two studies are of subject-matter-specific laptop programs. One of these programs is a study of writing among middle school students, and another study focuses on anatomy and physiology learning among a group of high school students. Finally, there is one study of a laptop program that is embedded in a larger districtwide reform effort.

Evaluation studies of discrete educational software programs for use at home and school, specifically Lightspan's *Achieve Now* software, are the second most frequently occurring type of program represented in the synthesis. Four studies met the methodological criteria for inclusion in our review. The six studies are of just three different multischool implementations of the program, in Wichita, Kansas and in Adams, Colorado.

Evaluations of laptop programs and Lightspan software may form the largest proportion of studies because of their popularity and the willingness of districts and vendors to pay for evaluation studies. The number of ERIC documents found by using the keyword "laptop" increased steadily from 1995 to 2000. This trend was reflected in part in the distribution of studies included in the synthesis by year, especially considering that 2000 may reflect–and 2001 does reflect–partial-year data owing to lags between study publication and entry into the ERIC database (Figure 4).

Figure 4. Number of Studies by Year of Publication



*Reflects partial year.

Districts and schools have spent considerable sums of money purchasing laptops or making purchases easier for families, and some districts (e.g., Beaufort and New York's District 6) have paid for comprehensive evaluations of their laptop programs to help justify these expenses and track success for accountability to program goals and community stakeholders. For its part, Lightspan has paid for two sets of studies (Gwaltney, 1998, 1999, 2000; Shakeshaft, Mann, & Becker, 1999). Vendors like Lightspan frequently pay for evaluations of their programs and post results on their Web sites; these evaluations help show teachers and potential school or district personnel that the programs may be effective in meeting schools' own goals for student learning. Studies of medical research have shown that vendor-sponsored research tends to report more positive results than other research, so vendor-sponsored study findings should be interpreted with caution. In addition, a number of studies funded by Lightspan and sent to us by the company did not have comparison groups or lacked a pre-post design; therefore; their results are not part of the analysis of outcomes.

In fact, not all the researchers included in our study reported information about how their studies were funded. Table 4 shows relationships between the researchers who conducted the evaluation studies in the synthesis and the programs they evaluated.

Table 4. Researchers' Relationship to Programs

Researcher(s)	Program	Relationship
Lowther, Ross,& Morrison	Michigan Laptop Program	Unknown
Metis Associates	District 6 Laptop Program	Hired by district
Myers	Title I Take-Home Laptop Program	Independent of program (dissertation)
Rockman et al.	Anytime Anywhere Learning Program	Hired by vendor
Schaumburg	German Laptop Program	Unknown
Schieber	Copernicus Project	Hired by vendor (dissertation)
Stevenson	Learning with Laptops (Beaufort)	Hired by district
Haynes	Laptops for Writing-Inhibited Students	Unknown (dissertation)
Siegle & Foster	Anatomy and Physiology Laptop Program	Independent
Light, McDermott, & Honey	Project Hiller	Independent (externally-funded)
Chang et al.	Project Explore	Independent (externally-funded)
Rockman et al.	Buddy Project	Hired by non-profit program
Gwaltney	Wichita Lightspan *Achieve Now*	Hired by vendor
Shakeshaft, Mann, & Becker	Adams 50 Lightspan *Achieve Now*	Hired by vendor

Better data are available across studies regarding the grade-level focus of programs. Nearly all the studies in the synthesis are evaluations of programs that serve primarily elementary or middle school students. It is important to consider the grade-level focus by program type. Seven of the laptop program evaluations took place in middle schools, and all of the Lightspan evaluations took place in elementary programs. (Lightspan programs are targeted primarily to students in the elementary grades). Although data on laptop programs nationwide are not available, our review found that most districts were implementing programs targeted to students in grades 6 through 8.

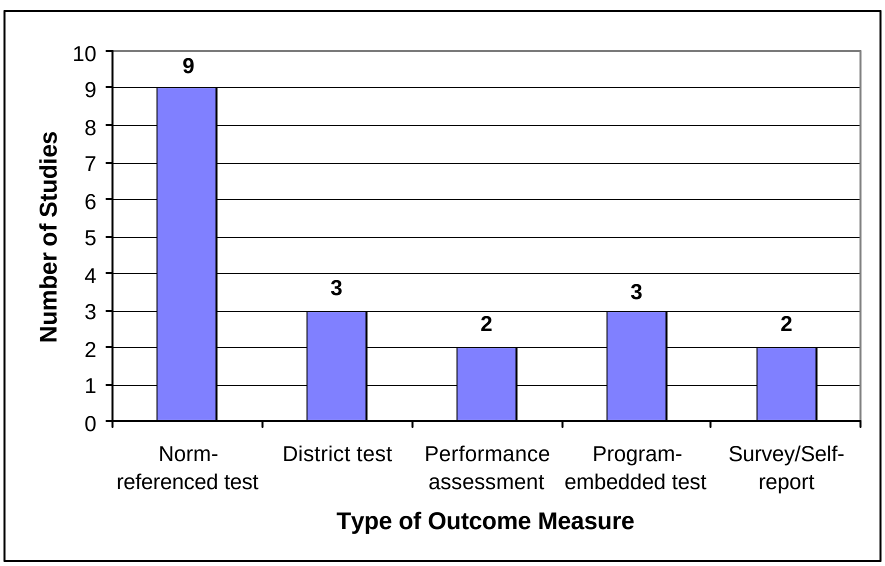
Some key program designs for linking home and school have yet to be researched. For example, we found no studies of computer recycling and repair programs, which are increasingly being implemented at the secondary level. In addition, we found no studies of the new Web-hosting services or student information systems that make communicating with parents about student progress easier. Some of these programs or products may be too new for evaluation studies to have been conducted. In addition, the parent-involvement-focused programs may be difficult to evaluate, since one must rely on parent feedback, often embedded within their interactions with the products, to assess program quality.

Outcomes Measured

The primary outcome that most of the studies in the synthesis measured was student achievement. Studies focused primarily on impacts of programs on reading, mathematics, and writing achievement. A few studies focused on student technology proficiency, student attitudes, or other measures of behavior (e.g., attendance). Just under a third of the studies included outcome data on parent involvement in the learning process or on parent-school communication.

Just under half of the studies relied on norm-referenced standardized tests to measure program outcomes (see Figure 5). There also were three studies that relied on district-level tests. Another three relied on program-embedded measures of success, that is, measures developed specifically for the program being studied. Two studies used performance assessments, and another two studies relied on survey or self-report measures.

Figure 5. Types of Outcome Measures Used in Studies

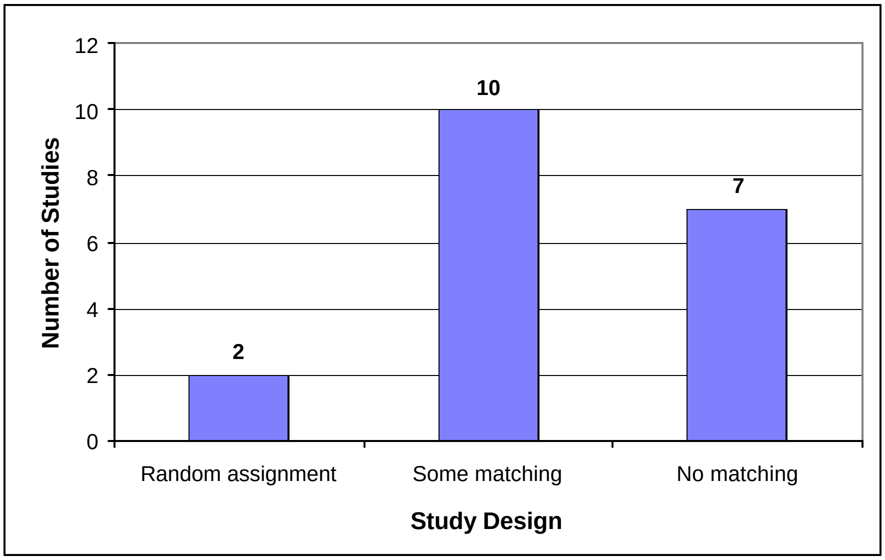


This report contains less information about the impacts of programs on parent involvement in the learning process and parent-school communication because fewer evaluation studies reported on these outcomes. Just seven studies reported any data on parent outcomes, and only two had enough data to compute the magnitude of the effect of programs. The most frequently used source of data about parents came from self-report surveys about parent perceptions, usually administered at one point toward the end of the program or school year. Our synthesis is not unusual having only a small number of studies reporting on parent involvement outcomes. In a recent meta-analysis, Fan and Chen (2001) observed that there are no widely used measures of parent involvement in children's learning, and though there are documented effects of parent involvement in student learning, educational research in this area is still in an early stage of development.

Study Designs

Only 2 of the studies randomly assigned participants to a treatment and control group. Another 10 studies attempted to match treatment and comparison groups on one or more dimensions, such as prior achievement or socioeconomic status. The most commonly used method (Figure 6) for matching treatment and comparison students was to identify students from similar schools in a district but in which the program was not being implemented (some matching). Three studies relied on a pre-post design with one treatment group.

Figure 6. Distribution of Study Designs



More than half (10) of the studies were longitudinal retention studies, that is, studies that "retain" data from multiple points in time on the same participants. These studies contained data on growth in student achievement over more than a 1-year period. In most cases, the gains analyzed were gains after students had participated for 2 years in programs. Four of the studies were cross-sectional and did not provide evidence of growth in student achievement over time.

Although many study designs attempted to match treatment and comparison groups in some way, most did not control for prior achievement or compare gain scores. Only one study used prior achievement as a covariate (Schieber, 1999). Although some studies checked to make sure that treatment and comparison groups did not differ on prior achievement (Stevenson, 1998; Gwaltney, 1998, 1999, 2000), these studies did not use prior achievement in measuring program results in their statistical calculations. Gain scores within the treatment and comparison groups were often conducted (e.g., Metis Associates, 1999), but no studies specifically compared 1- or 2-year gain scores of treatment students with gain scores of comparison students, using either a *t*-test or a 2x2 repeated-measures ANOVA.

The lack of statistical controls for prior achievement probably weakens the power of the statistical tests used to detect differences between treatment and comparison groups.

In some cases, comparison students may have been higher achieving than treatment students at the outset of the study, meaning that treatment students would have to significantly outgain comparison students just to find a measurable effect using Cohen's *d*, when it is unadjusted for prior achievement. At the same time, researchers have argued for correcting for over estimation of effect sizes calculated from such designs (Glass et al, 1981).

It is unclear from nearly all of the research designs whether program effects can be attributed to increased technology access or technology use at home or at school. Few studies provided any details about implementation and levels of use of technology at home or at school (cf. Giancola, et al. 1999, 2000, who relates use to program outcomes). In other cases (Gwaltney, 1998, 1999, 2000), students in the treatment group were all participants in another major school reform effort (Success for All) that targeted the same kinds of basic skill development as the treatment being measured. Finally, in at least two sets of studies conducted in a single district (Chang et al., 1998; Light et al., 2001), the researchers explicitly argued that gains in student learning cannot be understood outside the larger context of districtwide reform.

Location of Study Publication and Report Formats

Results from most research studies in the synthesis were reported in policy documents, rather than in peer-reviewed journals (Table 5). Just 1 of the 19 studies was an article that appeared in a peer-reviewed journal. More than half of the studies were either author-published reports or policy organization reports, nearly all of which were vendor- or program-sponsored evaluations. Other studies were conference presentations or dissertations. Over half (10) of all the studies were available on the Internet.

Table 5. Location of Published Studies

Location	Number of Studies
Peer-reviewed journal	1
Author-published report (available from vendor only)	4
Author-published report (available on Internet)	4
District-published report (available on Internet)	2
Conference presentation (available on Internet)	4
Conference presentation (available through ERIC)	1
Dissertation (available through UMI)	3

The authors did not uniformly include the statistical information needed to conduct a meta-analysis. Report formats and purposes resulted in exclusion of potentially difficult-to-understand parameters (e.g., standard deviations, t-values), as well as basic information, like *N*s (number of students in the study) and means, that were ideally included in published research. Key data needed to calculate effect sizes are missing from several studies in the synthesis. All but one of the longitudinal analyses conducted by researchers fell into this category; researchers reported mean 2-year gains in some cases, but variation in scores as measured by standard deviation and *N*s were often missing from these analyses.

Coders found evidence that such data were used in writing the reports, so we contacted 11 authors to collect these data. We were successful in obtaining data from four of these researchers. Some researchers told us they could no longer locate the data files; only one researcher did not respond at all. Data were missing from 6 of the 19 studies. Those studies are still included in the qualitative portion of the synthesis, because many of them contained implementation data and can still contribute to our understanding of the effect of programs that use technology to strengthen the links between home and school.

Summary of Coverage and Methodological Issues

The research synthesis includes studies examining the outcomes of programs across a range of program types and grade levels, but there were clusters of program types and grade levels that are represented better than others. For example, most of the laptop and desktop program evaluations took place in middle schools, where as all the evaluations of discrete educational software took place in elementary schools. In addition, some program types, like computer recycling and repair programs and newer commercial education programs that have a parent communication component, have not been evaluated.

Missing data and research designs that make drawing inferences about effectiveness impossible resulted in the exclusion of one-third of the studies from the synthesis. Nearly all of these studies used treatment and comparison group designs that attempted to match groups to ensure that the students in the programs were similar in important respects (e.g., prior achievement, family socioeconomic status) to students in the comparison groups. These studies relied mostly on norm-referenced standardized tests, district-level tests, and tests developed specifically to measure the effects of the program being studied. Those studies that were excluded from the quantitative analysis either did not include statistical information needed to conduct a meta-analysis or did not use designs that allow for the calculation of effect sizes. The small number of studies meeting the criteria for inclusion in the synthesis suggest that better research is needed to develop a better understanding of the effectiveness of the range of programs that seek to use technology to enhance the home-school connection.

Program Participation and Student Outcomes

Despite the limitations in study designs, the research studies that are analyzed in this report do converge in many respects as to the positive outcomes they report (see Norris, Smolka, & Soloway, 1999, for the significance of convergent evidence in educational research). Across the studies, there was evidence that program participation and student and parent outcomes were linked in ways that bear further investigation in new, rigorously designed studies. In this section, we examine more closely the impacts of technology-supported programs designed to improve student learning. We first report overall results and then report by outcome area for each program.

All of the effect sizes reported in this section should be interpreted with great caution. Because of the methodological limitations of the particular studies that are included in the review, the effect sizes are best understood as measures of association between program participation and particular student or parent outcomes that could be investigated more systematically in future research. Readers are encouraged to examine closely the Appendices and pay careful attention to sample sizes and confidence intervals in the tables, because the sample size impacts the confidence with which researchers can estimate particular effects.

Overall Results by Expected Program Outcome

When considering effects across studies, it is useful to examine results by type of program outcome. Knowing how student outcomes vary across measures and subject areas in the aggregate gives a useful birds-eye view of program effectiveness that also allows for comparison against other evaluation syntheses of the effects of educational interventions. Table 6 shows the results by outcome measured, in comparison with effects found in evaluation syntheses of educational interventions similar to the current study.

Table 6. Relationships of Educational Interventions to Achievement: Summary of Comparable Effect Sizes

Intervention	Mean Effect Size
Class-size reduction from 24 to 15 students	+0.13 to +0.18
Parent involvement program	+0.46
Individualization	+0.14
Coaching for achievement tests (e.g., SAT)	+0.25
Computer-assisted instruction	+0.31
Homework	+0.43
Tutoring	+0.50
Technologies that Link Home and School*	
Reading Achievement	+0.10
Mathematics Achievement	+0.23
Writing Skills	+0.34
Parent-School Communication	+0.23

Sources: Hattie, Biggs, and Purdie (1996); Levin et al. (1986).

* Mean effect sizes reported from the current study are weighted means adjusted for sample size.

As Table 6 shows, results in the area of writing are similar in magnitude to those reported in studies of the effects of computer-assisted instruction on student learning. Reported effects on mathematics achievement and parent-school communication were comparable to the reported effects of reducing class size from 24 to 15 students. The reported effects for reading achievement were somewhat smaller than the other outcomes measured.

Although Cohen (1988) would describe each of the effects of programs in the current synthesis as "small," their practical significance may be much greater within the field of education. Overall, their effects are similar in size to the effects of many other educational interventions widely believed to be successful (see Hattie et al., 1996). In some cases, the effects appear quite large and require careful interpretation. In the remainder of this section of the report, we examine more closely in what subjects programs were most effective and with which groups of students.

Reading Achievement

Overall, the technology-supported programs aimed at linking home and school more closely that we reviewed reported smaller effects than for other outcomes studies measured, though individual programs and sub-studies show quite different effects. Table 7 shows the effect sizes and confidence intervals by program for studies that examined reading achievement. The median (unweighted) effect size across all sub-studies was +0.08, and the weighted mean effect size was +0.10.

Table 7. Reading Achievement Effect Sizes, by Program (Treatment)

Study	Indicator(s)	Median Unweighted Effect Size (*d*)	Mean Weighted Effect Size (*d*)
Laptop Programs			
Project Hiller (Light, McDermott, & Honey)	HSPT Reading Scores (district test) (10th)	+1.26	+1.26
Learning with Laptops (Stevenson)	MAT7 NCErr* (8th)	+0.10	+0.07
Home Desktop Programs			
Project Explore (Chang, et al.)	Early Warning Reading Test (district test)	+0.16	+0.13
Discrete Software Programs			
Wichita Lightspan *Achieve Now* (Gwaltney)	MAT7 Reading	+0.06	+0.11

*NCErr is a composite score that includes reading and mathematics achievement levels. Stevenson (1998) did not report data on subscales of the MAT7.

The results of particular studies are at first glance surprising, because higher effects are reported for laptop programs than for discrete educational software programs, which have an explicit focus on improving reading. But both the laptop program and the Lightspan program were embedded within larger reform efforts that included a focus on literacy, and the different results may reflect the overall success of those efforts, rather than the effects of technology per se.

Two other sets of researchers whose studies are included in the evaluation synthesis but not factored in the calculation of the overall median effect size argued that the programs that they evaluated affected reading achievement positively. The evaluation of Project TELL, a home desktop program with the goal of improving reading achievement and long-term educational outcomes for low-performing students, reported gains of roughly 2 NCEs on standardized reading tests for Project TELL students from 5^{th} to 8^{th} grade, significantly higher gains than were achieved by a matched comparison group during the same period. A second study, conducted by Shakeshaft et al. (1999), argued for the benefits of Lightspan *Achieve Now* for students' reading achievement. Mean gains for Lightspan Year 1, Lightspan Year 2, and comparison students in reading were nearly equal, however. The authors concede that Year 2 and Year 1 gains are equivalent, though their conclusion is not that using the program for 2 years adds no benefit that cannot be gained from 1 year but rather that the achievement effects are "consistent and sustainable" (Shakeshaft et al., 1999, p. 14).[5]

The "true" effects of the programs reviewed in the synthesis on reading achievement may be larger or smaller than the mean and median effect sizes suggest. One must look at the confidence intervals for the calculated effect sizes to estimate the likelihood that the mean effect size is actually greater than zero (see Appendix E). The lower bound of the 95% confidence interval of all of the desktop program studies and all but one of the Lightspan studies is below zero.[6] Because error estimates for *d* are similar across these studies, the mean effect size for the studies is likely to closely reflect the "true" effects of Lightspan *Achieve Now* in the settings studied.

Mathematics Achievement

The reported effects of program participation on mathematics achievement across programs were somewhat larger than reported effects on reading achievement (Table 8). The median effect size (unweighted) across all studies of mathematics achievement was +0.23, and the mean weighted effect size was +0.18. The larger effect size for the weighted mean probably is due to the large *N* of the Stevenson (1998) study.

---

[5] This pattern of results is not uncommon in educational research. The most vivid and well-known example of this phenomenon can be found in results of studies of Head Start, where results are seen to fade over time (Lee & Loeb, 1995).

[6] The results of the desktop studies may be affected by the sample sizes for these studies, which are somewhat smaller than those of the majority of other studies in the review. Smaller sample sizes lead to wider confidence intervals.

Table 8. Math Achievement Effect Sizes, by Program (Treatment)

Study	Indicator(s)	Median Unweighted Effect Size (*d*)	Mean Weighted Effect Size (*d*)
Laptop Programs			
Project Hiller (Light, McDermott, & Honey)	HSPT Math Scores (district test) (10th)	+0.94	+0.94
Learning with Laptops (Stevenson)	MAT7 NCErr* (8th)	+0.10	+0.10
Title I Take-Home Computer Program (Myers)	Multiplication Fact Test Division Fact Test Chapter Math Tests (Heath Math Connections series) (3rd-5th)	-0.04	-0.01
Home Desktop Programs			
Project Explore (Chang, et al.)	Early Warning Math Test (district test)	+0.38	+0.43
Discrete Software Programs			
Wichita Lightspan *Achieve Now* (Gwaltney)	MAT7 Reading	+0.10	+0.09

*NCErr is a composite score that includes reading and mathematics achievement levels. Stevenson (1998) did not report data on subscales of the MAT7.

These results should be interpreted with caution, in that they do not point necessarily to increased technology access or use as causes of increases in mathematics achievement. Three of the 5 programs reported effects that are much lower than the other two studies. The highest effect sizes were from the Light et al. (2001) and Chang et al. (1998) studies of programs in Union City.

The studies conducted in Union City, New Jersey (Light et al., 2001; Chang et al., 1998) showed quite large effects—larger even than those of tutoring programs, which educational researchers have found to be among the most effective of educational interventions. But both sets of evaluators of the Union City programs were quick to note that the larger reform initiative in the district, rather than the technology, explains the magnitude of the effect. Light et al. (2001) in particular showed that in order to calculate the effect size for multiple analyses within a single study, additional data had to be gathered from reports. Much of the effect they found was attributable to differences in course-taking patterns unrelated to participation in Project Hiller (the laptop program). A higher percentage of students in Project Hiller than in the comparison group took an accelerated algebra course offered in the school district.

A closer look at sub-study results similarly suggests caution in interpreting the results as showing a positive overall effect of programs on mathematics achievement (Appendix F). The lower limits of the effect size confidence interval of all of the sub-studies reported in Myers' (1996) evaluation of a laptop program and six out of eight of Gwaltney's (1998, 1999, 2000) sub-studies of the Lightspan *Achieve Now* program were less than zero.

One other study not included as part of the analysis of outcome studies argued that the Lightspan *Achieve Now* program improved student mathematics scores. Claims from this study by Shakeshaft et al. (1999) are based primarily on comparing gains from fall to spring on CTB's *Terra Nova* test, which includes many extended problems and open-ended items. Mean gains for students in mathematics were nearly 6 NCEs above comparison students for Year 1 schools, and just under 3 NCEs above comparison students for Year 2 schools.

Writing Skills

Overall the reported effects of (mostly laptop and desktop) programs on student writing skills were higher than for mathematics and reading. Table 9 on the following page shows the median unweighted effect sizes and mean weighted effect sizes by program for writing achievement. The median effect size across studies was +0.20, and the weighted mean effect size was +0.34.

Table 9. Writing Achievement Effect Sizes, by Program (Cross-Study Analysis)

Study	Indicator(s)	Median Unweighted Effect Size *(d)*	Mean Weighted Effect Size *(d)*
Laptop Programs			
Project Hiller (Light, McDermott, & Honey)	HSPT Writing Scores (district test) (10th)	+0.39	+0.39
Copernicus Project (Schieber)	6-Trait Writing Assessment (5th-6th)	-0.12	-0.09
Laptops for Writing-Inhibited Students (Haynes)	Spelling, Capitalization, Punctuation, Sentence Problems, General Usage, Grammar, Style, Length of Writing, Writing Practices	+0.08	+0.16
Michigan Laptop Program (Lowther, Ross, & Morrison)	WLCS Writing Test (district test) (5th-6th)	+0.25	+0.25
Home Desktop Programs			
Project Explore (Chang, et al.)	Early Warning Writing Test (district test)	+0.45	+0.40

There are some important limitations to the inferences that can be drawn about program effectiveness from the studies reviewed. At least one of the studies that examined the impact of laptop programs on student writing relied on data collected in 1990-91, using a word-processing program with which users encountered several technical difficulties (Haynes, 1996). In addition, a number of laptop studies reported gains in writing skills but either did not measure writing skills directly (e.g., Stevenson, 1998) or did not report data needed to calculate an effect size (e.g., Rockman et al., 1998, 2000). Third, writing is a skill that is particularly difficult to assess well, and there is considerable evidence that both the assessment medium (computer versus pencil-and-paper) and the nature of the assessment task contribute to the results (Russell & Haney, 1997; Russell, 1999). None of the studies included in the research synthesis relied on actual samples of student writing generated as part of their ongoing classroom work but instead relied on timed writing tasks isolated from instruction.

Some laptop and home desktop studies reported gains in writing skills but either did not measure writing skills directly or did not report data needed to calculate an effect size. Stevenson (1998, 1999) discussed teacher reports of improved writing skills among laptop students for students in Beaufort's Learning with Laptops study. Rockman et al (1998, 2000) reported similar findings from teachers across a wide range of Anytime Anywhere Learning programs.

According to the Rockman et al (1998, 2000) studies, writing is one of the most frequent tasks students use laptops to support. Within the Microsoft-Toshiba programs, Microsoft Word was the most frequently used program, according to students and teachers. More than one-third of surveyed teachers named writing as the academic outcome or skill that had been most directly affected by use of the laptops (Rockman et al, 1998). Laptop students claimed to write reports and papers more frequently. Teachers reported that students were more willing to do the editing and reworking they would otherwise avoid. Laptop students also reported that they engaged more frequently than their counterparts in comparison classrooms in rewriting and rephrasing of passages from published documents, revising reports/papers before turning them in for a final grade, and writing an outline for a paper. In the third-year evaluation of the Anytime Anywhere Learning program, Rockman et al (2000) tested students' writing skill by comparing assessments of their responses to a writing prompt with those of a group of comparison students. In two of three classrooms, laptop students outscored comparison students on the writing performance assessment.

Rockman et al's (1995) earlier study of the Buddy Project in Indiana found similar benefits of providing greater technology access to students in the domain of writing skill. The writing study in this evaluation consisted of five 4th-grade and two 5th-grade Buddy classrooms whose teachers were part of a writing focus group. Part of the purpose of the writing focus group was to "share ideas about process writing as a process, technology, and home assignments that creatively merged the two" (p. 3). Three (two 4th-grade and one 5th-grade) classrooms were comparison sites. Both sets of classrooms were involved in teaching writing as a process, but the Buddy Project classrooms had the additional advantage of technology at home and at school, as well as targeted professional development for the teachers in technology integration. From an analysis of classroom-level differences, the report authors concluded that Buddy Project students' improvement in writing skills was greater than improvement shown in the comparison classrooms (Rockman et al, 1995).

The two Union City programs showed the largest positive effects, as they did in other subjects. Both the Light et al. (2001) study of Project Hiller students and the Chang et al. (1998) study of Project Explore students found positive effects on student writing scores, comparable to the observed effects of tutoring on student achievement (see Hattie et al., 1996). By contrast, most other effect sizes from studies of programs' impacts on writing had wider confidence intervals that included zero, and Schieber's (1999) second-year evaluation of the Copernicus Project actually showed a small negative effect of the laptop program on the organization of students' writing.

Other Learning Outcomes Measured in Evaluation Studies

Many of the programs studied noted other outcomes for students besides student achievement. Some studies examined the effect of programs on students' technology proficiency (e.g., Schaumburg, 2001). Others argued that laptop programs in particular had a positive effect on students' skill in conducting research (e.g., Rockman et al, 1998). Still others reported data on student attitudes (Myers, 1996), grades (Siegle & Foster, 2000), and school readiness (Gwaltney, 1998).

The largest effects were found for two programs. Schaumburg's (2001) study of a laptop program in Germany found extremely large effects of the program on students' technology proficiency. Even the lower limit of the confidence interval for this study was of a magnitude similar to some of the more powerful educational interventions studied (see Appendix H). Siegle and Foster's (2000) spring semester study of laptops in an anatomy and physiology class found smaller but reliable positive effects on students' mastery of content tested by their classroom teacher.

A number of studies point to the impact of broader home exposure to technology as contributing to proficiency with computers and the Internet. One of the goals of Project Hiller (Light et al., 2001) is to create a "cadre of technologically sophisticated students who can help advance the use of technology among peers and students," by involving students in service projects to departments that use their technology skills (e.g., class Web page design). Schaumburg's (2001) study of students in their second year of a laptop program in Germany with design features similar to those of Project Hiller found large effects for early teens on their self-reported computer knowledge. On the three dimensions tested on the instrument Schaumburg developed with her colleagues, the effect was greatest on student knowledge, especially of the software applications they used in the program, software that students are likely to encounter later in school and in the workplace. Gains for knowledge of hardware and operating systems and knowledge of the Internet approached significance.

More generally, some studies point to students' increased skill in conducting independent research and communicating the results among students who have greater access to laptops or desktops at home. For example, benefits of Project Hiller cited by teachers included the doubling of teachers' assigning work that required the use of presentation software for classwork in the past year, because they saw the potential of using this software in Project Hiller students' high-quality presentations of their research (Light et al., 2001). Lowther et al. (2001) found that students in a Michigan laptop program were more likely to be engaged in long-term projects than students in comparison classrooms (65% of laptop classrooms versus 22% of non-laptop classrooms). Moreover, students using laptops were more likely to be engaged in independent inquiry and research and in cooperative learning, and to use technology either as a means for instructional delivery or as a tool. Three studies examined the impact of laptop programs on student attitudes. Myers (1996) and Rockman et al (1995) examined how laptop use affected students' attitudes toward mathematics. Whereas the Myers study found no effect, Rockman et al reported that students in the Buddy Project defined math more broadly than comparison students, did more mathematics activities on their home computers, and wrote about math much more often. Though Haynes (1996) found few effects on writing achievement, he did find small to medium positive effects of laptops on students' attitudes toward writing and the degree to which they valued the writing process. As with other curriculum- and reform-embedded programs, it is difficult to ascertain whether the effects found in these programs are associated with computer use per se or with computers combined with new approaches to teaching.

The studies of Lightspan software's impact on younger students conducted by Gwaltney (1998, 1999, 2000) reported no significant effects of the program on students' scores on the Peabody Picture Vocabulary Test. This test is a measure of nonverbal intelligence often used to assess readiness for school. Gwaltney's studies across all 3 years of the program found no significant advantage to younger students using Lightspan *Achieve Now* software, compared with other students not using the software. In some cases, these younger students were in fact early readers in 1st and 2nd grades, a time when standardized tests in reading are typically also administered to students. Use of the Lightspan software might have been associated with gains in a test better matched to students' expected stage of literacy development.

Learning Outcomes Disaggregated by Student Characteristics

Overall effect sizes for studies and sub-studies may mask important differences in outcomes for particular subgroups of students. In the case of laptop and home desktop programs, in particular, which often are implemented specifically as strategies for improving equity of educational opportunity in schools and districts, it is particularly important to examine whether programs affect those groups of students specifically targeted by the intervention. In this section, we examine results across studies and program types for three groups of students: students from low-income families, girls, and low-achieving students.[7]

In general, the studies reported conflicting findings of the effects of programs on student learning for students from low-income families. Stevenson (1998) documented medium effects for students eligible for free or reduced-price lunch in Beaufort who participated in the Learning with Laptops program. He noted that these students' scores compared favorably with non-laptop students who were not eligible for free or reduced-price lunch by the end of their second year of participation in the program. Gwaltney (2000) found that 4th-grade students from low-income families who participated in the Lightspan *Achieve Now* program in Wichita outscored 4th-graders from families with similar income levels in a comparison group. At the same time, Gwaltney (2000) found no such benefit among 5th-graders from low-income families in his study. Myers' (1996)

[7] Data for results disaggregated by race are limited to one set of studies by Gwaltney (2000), in which sample sizes were below 20 per group.

study focused entirely on Title I students participating in a laptop program designed to improve their mathematics achievement and found no effects on mathematics learning. Appendix I shows the effect size of each sub-study focused on examining outcomes for low-income students.[8]

Evidence for the benefits to girls and boys participating in the programs was mixed, regardless of income level (Appendices I and J). Stevenson (1998) found positive effects for boys and girls participating in the Beaufort laptop program, and there was evidence of a small positive effect for girls using the Lightspan *Achieve Now* software among Wichita 4th-graders in the Gwaltney (2000) study. There also was a medium positive effect for boys in reading at the 4th-grade level in that study.

An interesting finding was reported by Schaumburg (2001), who noted that she found significant gains for girls in computer knowledge in the laptop program she evaluated in Germany. At the same time, gender remained a significant factor in computer knowledge, and girls' attitudes toward computers lagged behind those of boys both at the beginning and at the end of the study. Girls' general attitudes toward computers were less positive, and more resistant to change, even when given much broader exposure to technology through participation in a laptop program.

The available research makes it difficult to estimate the effects of programs on low-achieving students. Most studies of laptop programs included students who were relatively high achieving, with mean NCEs for reading and mathematics well above the national average (e.g., Metis Associates, 1999). Other studies used outcome measures that make it difficult to analyze how participants in the study compared with national norms, because the studies relied on district tests to measure achievement (e.g., Chang et al., 1998). Just one set of studies disaggregated results of programs for low-achieving students. Gwaltney's (1998, 1999, 2000) studies of Lightspan *Achieve Now* showed small to medium negative effects among 3rd graders in reading. At the same time, the effects of mathematics are less easily interpreted for low-achieving students (see Appendix M). The calculated effect sizes for several of these sub-studies were close to

[8] Although one sub-study conducted by Stevenson (1998) reported on gains for students who were not from low-income families, insufficient data were available to calculate an effect size for this subgroup.

zero. Moreover, this set of studies did not control for socioeconomic status, so it is difficult to estimate the true effect of the software on student achievement for low-performing students.

Overall, information available to interpret the effects of programs on specific subgroups of students is limited. In many cases, studies themselves focus on specific subgroups, such as low-income students (e.g., Myers 1996) or girls (e.g., Schaumburg, 2001), that do not allow for comparison with other groups of students. In other cases, as with evidence for low-achieving students, the effects reported in studies are mixed. Interpreting the effects of studies on low-achieving students is limited by the small number of studies that actually disaggregated results by achievement level. The best evidence does suggest that laptop programs and discrete educational software can benefit both boys and girls, but more research is needed that examines the effects of programs on specific subgroups of students.

We now turn to examine the effects of programs on another subgroup of the school community, parents. Parents can play a critical role in fostering student achievement (Fan & Chen, 2001), and a few of the studies included in this research synthesis had a component aimed at improving parent involvement in the learning process. As with the research on subgroups of students, this research is fairly limited in breadth and requires additional investigation into program effectiveness to understand the degree to which technology can enhance parent-school links.

Impacts of Programs on Parent Involvement in the Learning Process

A key goal for some programs in our study was improving parent involvement in their children's learning process. The strategies different programs used, however, varied significantly by program type. Standards for parent involvement in laptop and home desktop programs often were not well articulated, even if the hope was that such programs would result in parents' taking greater interest in their children's learning. By contrast, Lightspan encourages and prepares schools to implement a parent involvement component into their use of *Achieve Now* software. In this parent involvement component, parents can play Lightspan games with their children or engage in offline activities with them. Such activities are aligned with the software that students bring home from school.

In two studies that examined parent involvement in laptop and home desktop programs, parent involvement in the learning process was limited. Few parents in the District 6 laptop program worked on joint projects with their children: only 5% of students said they worked with their parents always or most times on their laptops, and 42% said they did sometimes (Metis Associates, 1999). Families participating in the Buddy Project spent more time negotiating individual time on computers than working together on the desktops, though parents said this scheduling helped create increased "family togetherness" (Rockman et al, 1995).

Gwaltney (1998, 1999, 2000) collected survey and interview data in each of the 3 years during which he conducted an evaluation of the Wichita Lightspan *Achieve Now* implementation. Across all 3 years, he found that teachers and parents endorsed the idea that the program had a positive impact on family involvement in school-related work. Teachers did have somewhat lower ratings of the program's impact on parent involvement than did parents. In the Year 2 evaluation, Gwaltney (1999) reported that just over half of all teachers surveyed agreed with the statement that the program had increased parents' involvement in the learning process. Teachers who gave lower ratings of the program focused on problems with the "home" aspects of the program; they wanted more parent involvement, or they made comments about Lightspan homework not being complete or CDs not being returned from home.

None of the studies we reviewed measured parent involvement in the learning process with a quasi-experimental or experimental design. Instead, researchers used interviews and one-time teacher surveys to examine parent involvement in the learning process, such as those conducted by Rockman et al (1995) and Gwaltney (1998, 1999, 2000). Because of this limitation, it is difficult to estimate the effect of programs on parent involvement in the learning process, and research from different programs using Lightspan *Achieve Now* points to different interpretations about the benefits of using the software at home with parents. Gwaltney's (1998, 2000) studies are more positive in their estimation of the program's effects on parent involvement, but his 1999 study points to limitations in implementation of the program's home component that might limit its impact on parent involvement.

Impacts of Programs on Parent-School Communication

Improving the level and quality of parent-school communication is the main purpose of voicemail programs, and at least one of these programs in all likelihood had small to medium positive effects. The mean weighted effect size overall (+0.18) and median effect size (+0.23) both suggest a positive effect comparable to the effect of reducing class size (Appendix L shows results of each sub-study).

Cameron and Lee's (1997) study of a voicemail program in Canada examined the impact of the system on parent-teacher communication. Two small studies were done: a 3-week pilot with 24 upper-middle-income families and a 6-week intervention with 44 families from more diverse socioeconomic backgrounds. The students were all in the elementary grades from schools in a single region of Canada.

On average, Cameron and Lee (1997) found that the voicemail group contacted their teachers 0.7 times per week over the intervention period, compared with 0.5 times per week for the comparison group. Voicemail was used in the majority of those contacts for the treatment group. Parents received an average of 1.2 messages per week from teachers, compared with 0.5 messages per week for comparison parents. Although the number of messages is not large, the increase represents a doubling of parent contacts with the school. Just as notable, 46% of parents in the treatment group felt there was an improvement in home-school communications, compared with 16% of comparison parents. Moreover, 23% felt there was a change in teachers' knowledge of parents' homes in the treatment group, compared with 11% in the comparison group. Results of a similar magnitude were found in studies of the Transparent School Model by Bauch (1994). In this earlier study of a voicemail program, Bauch found that significantly more parent contacts were associated with implementation of the program.

Myers (1996) examined the impacts of a laptop program on parent-school communication but did not find the positive results that Cameron and Lee (1997) found. Myers (1996) noted that use of the laptops was unstructured in the program, and neither teachers nor parents were clear about how they were to be used; therefore, the fact that no effects on parent-school communication were detected is not particularly surprising.

In summary, the effects of technology programs designed to enhance home-school connections on parent-related outcomes are not well understood. A few studies have found positive effects of voicemail programs on parent-school communication, but the impact of other types of programs on parent-school communication, such as laptop or home desktop programs, on parent-school communication is unknown. Survey data are the only source of evidence about whether software programs like Lightspan's *Achieve Now* have their desired effect of enhancing parent involvement in the learning process. Although parents do believe that using the software on their involvement has a positive impact in their child's learning, other evidence points to the fact that the home component of the *Achieve Now* software typically is not widely implemented. More research is needed that describes in greater detail the processes of parent involvement and communication that are affected by these programs and how use of new technologies might lead to significant effects on parent outcomes.

How Programs Are Implemented: Findings from the Case Studies

To identify issues faced across programs in implementing their designs for increasing home access to technology or using available technology to link home and school more closely, we examined implementation data from the research studies and our case study debriefing forms. We identified themes that were common to three or more programs or studies, as well as themes that distinguished programs either within their program types or across program types. In this section, we discuss these themes in greater detail through a presentation of three different cases that illustrate the range of programs we examined. The three programs we have selected are representative of the range of programs we visited and are presented here to illustrate issues related to program goals and design, use of technology in the programs, preparation of teachers and parents, and sustainability.

The three programs selected represent three of the most commonly adopted approaches to using technology to link home and school. The Laptops for Learning program is a *cross-curricular laptop program* that began in 1996 in Beaufort, South Carolina. The use of Lightspan *Achieve Now* at the Family Technology Centers in Blackfoot District #55 in Idaho is representative of programs that aim to link home and school through *discrete educational software.* Finally, Learning Network's myschoolonline.com represents an emerging popular approach to linking home and school, *commercial education products targeting home-school communications*. We present each of these cases in turn, followed by a brief discussion of implementation issues common to the cases and directions for future research.

The Learning with Laptops Program (Beaufort, SC)

In 1995, a group of teachers and administrators the Beaufort County School District in rural South Carolina visited schools in Australia that were experimenting with providing laptop computers to their students. The group from Beaufort were so impressed with what they saw in Australia and with the potential of laptops to support their district's educational goals that within a year, Beaufort decided to join the schools and districts becoming part of the then-new Anytime Anywhere Learning program, sponsored by Microsoft and several hardware manufacturers, including Toshiba. Beginning in 1996, through its Learning with Laptops initiative, the district has made it possible for thousands of students in the county's public middle schools to lease laptops for use at home and at school.

The Beaufort County School District is located in the southern tip of South Carolina, along the Atlantic Ocean, and registers approximately 17,000 students. The district is geographically dispersed, spreading over 800 square miles, and includes more than 60 separate islands. Across the district, roughly half of all students are eligible for free or reduced-price lunch. However, overall figures hide the fact that the district has scores of students who live in remote rural areas and come from families that struggle to survive economically, as well as students who live in resort areas and come from families with relatively high incomes.

When the program began, many of Beaufort's low-income families could not afford to buy their children a computer to use at home. Moreover, the vast majority of its students were miles away from a local public library and from other resources that could support students conducting research for projects going on at school. Educational leaders in the school district believed that a laptop program could provide all students with equitable access to new information on the Internet, regardless of where they lived or their schools' or families' financial resources. According to Herman Gaither, superintendent of schools in Beaufort,

> We have got to give people access to information. Putting a library in the middle of a town, and the library's still 20 miles for some kids to get to and from, doesn't do a lot…So for us, the technology, particularly laptops, it becomes a means of creating that Web [of information].

Goals and Program Design

The Learning with Laptops program has two primary aims: to provide *access to technology* and to ensure *equity of access to information* to its middle school students. Initially, the hope was to provide computers to all middle school students in three middle schools, though many parents have opted not to participate in the program, which is the most popular of several "programs of choice" within the district. The district's interest in providing *access to technology* is to put 21st century tools into the hands of students, to help prepare them for the future. The district's interest in providing *equity of access to information* is to help overcome difficulties in serving this geographically dispersed student body through physical libraries and information resources. With the Internet, students on the mainland or any of the many islands in this district can have access to information anywhere in the world, not just what is available in their own home or in the small public libraries in the communities of Beaufort or Hilton Head Island.

The Learning with Laptops program's goals are similar in many respects to the goals of other laptop programs and home desktop programs we visited as part of our study. All of these programs have an underlying concern with equity—namely, providing low-income students with the kinds of tools that will enable them to obtain and use digital information to support their own learning. All of these programs, moreover, were started in schools, districts, or states where many students did not have technology access at home at the outset. Laptops or home desktops were one strategy to overcome what has been called the "digital divide," a division within America between households with and without computer and Internet access associated with differences in income levels, region, urbanicity, and race, among other factors (NTIA, 1999).

Addressing Inequities in Access to Technology at Home and School

To ensure that low-income families in the district could participate, district leaders successfully built support among teachers, parents, and community groups for a vision of providing laptops to all middle school students in the district. District officials lobbied for passage of a countywide bond issue that would provide initial funding for a laptop program and for the creation of a community foundation that would support the mission of increasing technology access to all students in the school system. The bond passed, and the Schoolbook Foundation was established and charged with helping to coordinate the program and with managing the financial aspects of the program.

Through subsidies from the SchoolBook Foundation, the district has been largely successful in providing technology access to low-income students. For most of the life of the program, the Schoolbook Foundation has leased laptop computers to families on a sliding scale. Through subsidies from the foundation, low-income families have been able to lease computers at a monthly rate of roughly $30, and if they made all their payments over 3 years, they would own the laptops when their children graduated from middle school. As a result, the proportion of students opting to participate in the laptop program who are eligible for free or reduced-price lunch is roughly equal to the proportion of all students in the district who are eligible for free or reduced-price lunch.

How Laptops Are Used in Beaufort

When students select a middle school, their parents can select one of several "programs of choice" in the district that allow students to benefit from more intensive study in a particular area, such as the humanities or environmental science. The Learning with Laptops program is one of those programs of choice, and students who opt into this program lease a new laptop computer beginning in 6^{th} grade, which they keep throughout their middle school years. One unintended consequence of the program's design is that older middle school students with more status in the school have older, slower computers than younger students. This situation causes some envy among older students, who see the newer, faster, and more powerful laptops and wish they could have them for their own.

Students use the laptops throughout the school day and at home, primarily for conducting research, doing homework, and writing reports in English, science, and social studies. Students we interviewed said the primary benefit of laptops to them had been to help familiarize them with using a computer. They also believed that it had reduced the length of time they had to spend searching for information and had made their papers more readable for teachers. An 8^{th} grader said that his skill with using a laptop helped earn him more popularity among his peers and respect from his teacher.

Some of students' most memorable projects on laptops involved research tasks. For a student at the humanities school, a particularly significant project involved research on an African-American soldier from a regiment in the Union Army stationed in South Carolina. As part of the project, he had to research different sites for bias in reporting on the Civil War. He learned how to identify bias for and against different perspectives on the war by looking carefully at language and symbols used on Web sites.

Teachers reported significant benefits to assigning homework that requires the use of computers, such as research projects that require use of the Internet or papers and projects on topics the class is studying. Teachers at one middle school in Beaufort reported that with access to computers, students did a better job on their homework and completed it more often. In addition to serving as a tool to help students do the work, the computer facilitates students' access to assignments and information that they did not get in class. Teachers said students turned in more detailed and carefully presented reports that suggest students are spending more time on research than they did before laptops were more widely available.

One problem that evaluation studies of the program have found to be significant for teachers is that not all students in a particular class have laptops (Stevenson, 1999). The program is not schoolwide, and even students with laptops do not always bring their computers to class. Teachers and students complain that the weight of textbooks students must carry sometimes makes students' book bags so heavy that they don't want to add to the weight of their bags by bringing a laptop to school. To adapt to this situation, teachers in laptop middle schools in Beaufort have developed two ways to complete many assignments, a "computer" way and a "non-computer" way. Teachers said that at first, developing two forms of assignments required more work, but over time, they've found that requiring students to be able to do an assignment both by hand and with a computer increases students' own flexibility in problem solving.

Maintenance and Technical Support

For day-to-day problems with laptops, the program is dependent largely on school staff to troubleshoot problems that arise. For bigger problems, the district's technology staff are available to try to help, as well. In addition, Beaufort contracts with an out-of-state company to provide routine maintenance of its laptops; additionally, once a year, the company sends representatives to do thorough maintenance and repair of the program's equipment. The program also provides loaner computers to students whose computers are being repaired.

The district reported that technical problems with laptops were limited in scope; the most common problem was crashed or full hard drives. Many students overload their hard drives with programs and multimedia files. For their part, students complained that their most common problem occurred when AC adapter cables broke. Program staff reported that maintaining adequate "up time" for laptops had been an issue for a number of participants, a problem identified also by students in the program.

Though skeptics of laptop programs often worry that laptops that students can take back and forth from school and home are more likely to be stolen than desktops that remain at school, program leaders reported that theft was not a significant problem. Barbara Catenaci, program director, noted that fewer than 1% of laptops have ever been stolen. To prevent theft, the district uses a national tracking system, which has worked successfully to return some missing laptops.

Preparing Teachers to Integrate Laptops into the Classroom

When the program first started, teachers in the 6^{th} grade were given training to prepare them for the first cohort of students to receive laptops. Seventh-grade teachers weren't given training until the second year, when students who had been in the program for a year entered their classes. Finally, in the third year, teachers in 8^{th} grade were given training in how to integrate laptops into the classroom. The staggered training meant that teachers who were more novice level in their ability to integrate technology into classroom practice were getting students with higher levels of expectation of computer use in the classroom. By the third year of the program, students felt that their 8^{th} grade teachers were less likely to require them to use their computers for school use than their middle school teachers (Stevenson, 1999).

At present, there are extensive training opportunities for teachers in how to integrate technology into instruction in the district, though little is targeted specifically at the use of laptops. District leaders have established three levels of training they aim to provide teachers within the district. First, they hope to train all teachers in basic proficiency. To encourage all teachers to reach this level, the district promises access to new kinds of technology resources on attainment of basic technology proficiency. At the second level, teachers are encouraged to learn how to use specific applications (e.g., word processing, spreadsheets) for their own productivity. Finally, at the third level, the focus of training is on technology integration to support standards-based instruction.

Teacher training has been provided through the technology department in Beaufort, and course credit for teachers is available through the University of South Carolina-Beaufort and through the College of Charleston, which is some 100 miles away. There is a strong literacy focus within the district, and staff development opportunities related to technology also reflect that focus.

In addition, to augment its laptop program, the district is investing in a new program called MUSTT (Mobile Units for Sustained Technology Training). The program, as its name suggests, trains teachers to use technology on their own school sites by offering a combination of pull-out training in a technology-rich mobile lab and direct classroom assistance. The lab will be equipped with eight laptops and one instructor, who will give 20-minute mini-lessons on using technology.

Preparing Parents for Laptops

For students and their parents in Beaufort, training is much less extensive. Students and parents are invited to an initial meeting detailing how to care for their computers, but beyond that, there is little outreach to families. Students are fairly proficient in learning to care for their own computers, even if they sometimes ignore warnings about downloading large files that fill up hard drives, but parents are not always so skilled, nor do they always feel well informed about how their students are using laptops at school. One parent we interviewed complained that the laptops were not used enough; she had extended her family financially to lease the laptop and wanted to see a greater return on her investment in terms of higher computer use at school.

Challenges in Sustaining the Program

As the Learning with Laptops program matures, it faces many new challenges. At present, the SchoolBook Foundation, the community foundation designed to help subsidize leases to low-income students, is more than $2 million in debt. When the foundation began to run into financial troubles a few years ago, the district stepped in to support the effort. The district's reserve and capital funds have been covering the debt, though the superintendent expects the foundation to be self-sufficient within the next 5 years. Because of its difficulties, the foundation is unable to offer the same level of discounts to low-income families as it has in the past. The cost for each family for participation in the program was initially set on a sliding scale, depending on income. Now, low-income families leasing a used laptop must pay $25 per month per student to participate. This type of cost-cutting measure, along with awards from grants and other sources, while reducing opportunity in the short term, may help the financial prospects of the SchoolBook Foundation over the long term.

Support among student participants is important as well and has proven difficult to sustain as students grow older. This difficulty may be due to a decrease in novelty. Teachers in Beaufort, in particular, mentioned that students bring their laptops to school less frequently than previously because "the novelty has worn off." Several other factors seem to contribute to the effect of a decrease in novelty. As their textbooks grow bigger, students in laptop programs report feeling burdened by having to carry heavy computers to, from, and around school (Stevenson, 1998, 1999).[9] Also, in the lease-to-own

[9]To reduce students' load, program staff in Beaufort have lobbied policy-makers to encourage textbook publishers to make more titles available online. Several textbook publishers are exploring doing so (Walsh, 2001), and the state of Texas has considered replacing its textbooks with online versions.

arrangements used by both laptop programs studied, families begin payments for the new laptops when their children are in 6th grade and complete these payments when the students are in 8th grade. By then, however, the laptops are not top-of-the-line computers. These students are discouraged to see 6th graders in the programs using newer, faster, lighter machines (Stevenson, 1999).

Learning with Laptops' challenges to sustainability are, in many respects, the challenges faced by a successful program. The district's vision of increasing technology access for low-income students has largely been a success. Before subsidies to low-income students were reduced, some 60% of laptop students were low-income students, in a district where roughly half of all students are eligible for free or reduced-price lunch. Evaluation studies have shown that the program has been successful in boosting student achievement, as well (Stevenson, 1999). But being able to help low-income families pay for laptops over the long term remains a significant hurdle for Beaufort to overcome, and advances in educational technology have raised teachers' and students' expectations of what is possible. The long-term future of Learning with Laptops as a program depends on how it addresses these issues.

Lightspan Achieve Now *at the Family Technology Centers (Blackfoot District 55, ID)*

Achieve Now, one of the most popular educational interactive software packages, uses visually rich games to teach basic academic skills in reading/language arts and mathematics. The aim, according to company officials, is to harness the motivation students have for attending to animations, cartoons, and multimedia products to improve learning outcomes. The games come on CD-ROM, are also available online for districts that purchase the program, and include an integrated assessment system. Districts can access professional development materials online at the Lightspan site or have company staff provide them with training. The software's use is included in this research synthesis because there is a home component to the program; students may check out the software on Sony PlayStation cartridges and play the games with their parents or on their own at home.

Many schools and local education agencies around the country have purchased Lightspan *Achieve Now* software as a support to basic literacy and mathematics instruction at the elementary level. Some programs implement *Achieve Now* as an integrated part of a district-or schoolwide effort to improve achievement (see Gwaltney 1998, 1999, 2000); while others use the software within individual classrooms, largely as a supplement or add-on to their literacy or mathematics curriculum. Our case study site, the Family Technology Centers in Blackfoot District #55 in Idaho, represents a blend of these two approaches to implementing the software.

The Family Technology Centers (FTCs) are two school-based centers funded through the U.S. Department of Education Community Technology Centers program. They are located at Stalker Elementary School in Blackfoot and at Fort Hall Elementary in Fort Hall, both in Bingham County, Idaho. The FTC at Stalker and the FTC at Fort Hall were established in 2000 to provide young people and adults in their communities with access to technology to meet two of the most pressing needs of these communities, improving achievement and building job-related skills.

Blackfoot's Goals for Using Achieve Now *and Program Design*

One challenge that both Blackfoot and Fort Hall have in common is literacy development. Reading scores at both Stalker Elementary and Fort Hall Elementary are below national norms, and high levels of poverty among students' families make it more challenging for teachers to help meet students' basic needs while holding high expectations for achievement. Both schools receive federal financial aid from both Title I and Title XII block grants to support programming, but the Community Technology Centers grant has allowed the schools to extend learning in the school day in ways that were not imagined before the grant.

The school district purchased Lightspan *Achieve Now* software for the FTCs at Stalker and Fort Hall primarily to build literacy skills. Students use the software during their regular school day in the school-based lab that was built with funds from the grant, as well as after school. On a given afternoon, both centers may be filled after the last bell rings with students working individually at workstations, each on different academic games that comprise the program. To participate, children simply must submit permission slips from a parent and/or teacher to use the center.

The Family Technology Centers' program design is based on what co-Director Dr. Betsy Goeltz calls a learner-centered model. The centers aim to provide as much individualized support as possible for learning with technology. Consistent with this approach, teachers gear the use of *Achieve Now* software toward individual students working on the specific activity that best suits their individual reading and math needs during the school and after-school hours.

Addressing Inequities in Access to Technology at Home and School

A chief aim of each of the Family Technology Centers, like that of many other community technology centers, is to reach across the "digital divide" by providing technology access at a public location for people who otherwise would not have access to computers or the Internet (see Penuel & Michalchik, 2001). Both centers attempt to reach out to community members who do not have technology access at home by offering classes in basic computer use in the evenings. And by extending the school day to provide technology access to children at the FTCs, the program extends the opportunities for many Native American and Hispanic children from low-income families to use technology to aid learning.

Participating in the home component of Lightspan *Achieve Now* does not require students to have a computer or even Internet access at home. Families do need a television set, in order to use the Sony PlayStations to play the games students can take home. This turns out to be a benefit to schools like the one we visited on the Shoshone-Bannock Reservation in Fort Hall, Idaho, where many Native American families lack computers and sometimes even telephone service. In these programs, the decision to make the technology "threshold" low for families is a conscious one (Bauch, 1994) in order to maximize opportunity for families that are least likely to have good technology access at home.

How Achieve Now *Is Used at Blackfoot District #55*

Both teachers and after-school staff facilitate sessions where students use the software to supplement instruction. Classroom teachers are encouraged to sign up for slots during the school day to bring their classes in to use the Lightspan software. Several teachers we interviewed liked both the flexibility and the content of the software. Sandra Rainey, a 1^{st} grade teacher at Fort Hall Elementary, noted, "The program gives me flexibility in the areas of classroom management and instruction, and helps to meet the individual academic needs of the students. Not only do the children enjoy the programs, but I do too!"

The after-school sessions are run differently at each of the FTCs, because more children are able to attend at Stalker than at Fort Hall. Not only is the space somewhat smaller at Fort Hall, fewer children typically attend each day. As a result, at Fort Hall, the after-school program director is often able to give each of the students one-on-one attention as they use Lightspan's Internet-based games. Many of the students do not use their headphones and work together on their activities. At Stalker, more children come in, and they each line up to get their own CD and get to work on their own. The after-school director is able to handle questions from students, but there are too many students for him to be able to monitor what each student is up to with the software.

Students' use of the Lightspan *Achieve Now* software appears to be limited largely to use of the software in class and after school. Although both the Stalker and Fort Hall FTCs have bought the Sony PlayStations that would allow students to take home CDs, rarely are more than one-quarter of the 20 or so PlayStations checked out by students. In this respect, the program is not that different from even those districts that use Lightspan to support school reform more widely, where teachers report that the parent or home component of the program is not as well aligned as it could be with the classroom component (Gwaltney, 1999).

Maintenance and Technical Support

The greatest cost to a school or district that decides to purchase the Lightspan *Achieve Now* software appears to be the up-front cost of purchasing the software. Although CDs do need to be replaced from time to time, the cost of replacing software is much lower than the initial cost of buying the software, which Blackfoot District #55 staff estimate cost them $10,000 to $15,000 per grade level.

The FTCs rely on the school district's infrastructure for technical support. Center directors reported that the Internet connection was rarely down, and computers that were broken at Stalker have been replaced fairly quickly by the principal. Both have access to the school district's two full-time technical support personnel. These personnel serve nine schools and are supervised by the overall director for the project, who is also the district technology coordinator.

Preparing Teachers to Use Achieve Now *Software*

Teachers in Blackfoot District #55 have spent considerable time in training sessions devoted to learning how to use the Lightspan *Achieve Now* software. Teachers at every level at Stalker Elementary have been trained in its use, and a school-wide training for teachers at Fort Hall Elementary was scheduled for fall 2001 as part of a comprehensive school reform plan. The teachers interviewed at Stalker who had been through the training saw a strong benefit from becoming familiar with the variety of games and the levels of skill required for each, so that the teachers could implement them as part of their work in the classroom and the technology lab at the school.

The staff of the Family Technology Centers have had multiple opportunities to participate in other kinds of professional development, as well. In addition to training in the use of Lightspan, an independent company has provided one-on-one training to the center directors in Operating Systems, Basic Applications, File Management, Word Processing, Spreadsheets, PowerPoint, and Internet. An upcoming training is scheduled on Photoshop. Center staff have also participated from time to time in the district's "Snippets" of training. These afternoon sessions focus on a small aspect of using technology in the classroom. Selected course offerings cited in the evaluation report include "Enhancing Language Arts Through Technology," "Creating a Portfolio," "Beginning Hardware & Troubleshooting," "Multimedia Development – HyperStudio," and "Integrating Technology in Math."

Through their training and their own learning, the directors of the FTCs, as well as nearly all the teachers at Stalker and Fort Hall, have met Idaho's requirement for teachers to become technologically proficient. Idaho requires schools seeking reaccreditation to show that at least 80 % of their teachers have passed the state's proficiency requirement, either by passing a state-mandated test or by submitting a portfolio demonstrating proficiency with technology. Blackfoot District #55's leadership in technology, evidenced by its successful U.S. Department of Education Technology Innovation Challenge Grant and Community Technology Centers proposals, prepared its teachers well to meet these new state requirements, and both Stalker and Fort Hall are well on their way to meeting the reaccreditation requirements.

Preparing Parents to Use the Software

Parents in the two schools where the FTCs are housed are given opportunities to attend introductory sessions on the software. In some cases, individual teachers may encourage students to take CDs home, but the home component of Lightspan *Achieve Now* is not emphasized as strongly as the in-school and after-school components intended to supplement instruction. As a result, school staff reported that few parents actually checked out Sony PlayStations at either Stalker or Fort Hall, both of which are schools where parent involvement historically has been low, especially among students from low-income families.

By no means is the limited involvement of parents in using the software unusual. Across the range of Lightspan *Achieve Now* implementations studied in our research synthesis, participants reported frustration with weak links between the classroom curriculum and what takes place at home (Giancola et al., 1999; Rockman et al, 1995). Although these programs intend to strengthen ties between classroom and home, benefits are reported to be felt most strongly by communities that already have strong family involvement in school activities and programs.

Challenges in Sustaining the Program

At present, the FTCs are in their third year of federal funding from the U.S. Department of Education's Community Technology Centers program. The grant has helped to pay for the Lightspan *Achieve Now* software, but the school district and schools have helped pick up a number of other costs of maintaining the program, including the facilities costs (e.g., utilities), furniture for the centers, and replacements for computers that either had become old or had broken.

The schools and district are committed to keeping the after-school program going, but it is also likely that the program's ability to sustain itself will depend on crucial community support. Many community organizations from different sectors are involved in the Family Technology Centers, both advising project co-directors on programming and providing referrals and links to and from community services. Representatives from the school district's technology and vocational offices, employment and job training centers, local businesses, advocacy groups for migrant farm workers, and the Shoshone-Bannock tribal council all gave input to a needs assessment, initiated by the co-directors to explore the need for a community technology center. Leveraging these partnerships to sustain the broader initiative to keep the FTCs open in the after-school hours will be necessary to make the Lightspan *Achieve Now* software available to more students who are less likely to have or to use a computer at home for educational purposes, especially if levels of home use of the CDs remain low.

Learning Network's myschoolonline.com (National)

Commercial education products that facilitate more frequent and easier communication between parents and school represent a way that technology is increasingly being used to link home and school more closely. Companies like Apple, NCS Pearson, and Learning Network have developed services in recent years that allow schools and parents to communicate information via the Internet and e-mail. These products and services are too new to have been researched for their effectiveness; nonetheless, a case study of one such service is included in this research synthesis because the growing investment of companies in providing such services suggests that policy-makers soon will be asked questions by parents, teachers, and school leaders about their effectiveness.

Myschoolonline is a popular Web hosting service for districts, schools, teachers, PTA and other community-based organizations. According to Learning Network, the site's parent company, successful myschoolonline Web sites are those that support integrating the Internet in the learning process of students and/or parents, mastering online communication between the school and home, and increasing parental involvement in schools and classrooms. The site offers an array of free features, including Web development tools and tutorials, content galleries of ready-made activities, and a "best practices" showcase of model sites. In the past year, myschoolonline.com has grown to host the Web sites of more than 50,000 schools, districts, teachers, PTAs, and community-based organizations.

Learning Network's president, Mark Nieker, argues that school Web sites are important not only to increase communication with parents and provide resources to their students while at home but also to allow schools to participate in the larger Internet community. Teachers have the ability to look in on each other's classrooms, use the site's resources, get new ideas, and publish best practices. The company has embedded additional resources throughout the site to meet the specific needs of teachers, administrators, PTA members, community group leaders, parents, and students. For example, the parents' section includes articles such as how to "be a test-savvy parent" and links to Learning Network's main site which offers homework help and message boards providing suggestions from other parents. The teachers' section includes links to a quiz maker, information about mygradebook.com, and a "teacher tips" newsletter.

Although the some districts use myschoolonline to host Web sites at schools throughout the district, most sites grow organically from teachers' classrooms, spreading by word of mouth as teachers use the online tutorials to give the process a try and tell others. For this case study, we focused on school and classroom use in three California schools. The first, Saint Catherine of Siena School, is a K-8 Catholic school serving the Filipino community of Vallejo and the surrounding area. The second school is a suburban Southern California public school in a gated community of Las Flores. The third is a public, low-income urban charter school in San Francisco. In the Las Flores and San Francisco schools, the one teacher we interviewed at each school, a 5th grade teacher and an English teacher, were the only teachers who had developed class Web sites using myschoolonline.com.

Teacher Goals for Using myschoolonline.com

Teachers reported that they had goals similar to those of program designers at Learning Network for using myschoolonline, namely, to support homework, to increase communication with parents, and to provide an audience for student work. St. Catherines' was looking for an easy-to-use way to post school announcements and activities on the Web, put lessons and supporting materials online for students to use at home, and publish student work for a larger audience. Initially, two teachers organized the 8th grade to use myschoolonline for their classrooms. It has since spread by grade level down to the 1st grade and now includes nearly all classrooms in the school.

Teachers at the other two schools reported that their goals for classroom sites had shifted as they discovered new uses for them in their classrooms. The teacher in San Francisco hoped that her site would help students become more organized and accountable. She reported homework return rates as "painfully low," and a teacher at another school suggested she build a site on myschoolonline. She designed her site so that students and parents could look up homework assignments and schedules on the Web when they forgot or could not find their binders. However, she found it difficult to keep up the site and was not sure how many students relied on the Web site. She now uses her site primarily to post student work.

In Las Flores, the teacher's initial goal for using Learning Network's myschoolonline was to put her homework assignments up on the Web for parents and students to view. The school's PTA had a site with a link, so she read about it and signed up. She said that the process was easy: "I was on the Web in 5 minutes…I just had to answer a few questions to fill in the forms." Her goals have grown since she has seen the site influence students. In addition to providing information on what's happening in her classroom to parents, her site now has many other resources and activities. She described one of the most important goals of the site now as being to increase student self-esteem by hosting a gallery to show exemplary student work.

Addressing Inequities in Access to Technology at Home and School

The digital divide has a major impact on the ability of Web-hosting services such as myschoolonline to connect home and schools. In schools with high levels of home connectivity and parent involvement, such as the Las Flores elementary and St. Catherine's, classroom Web sites can become an important tool to support classroom and school activity. But in other locations, such as in urban San Francisco, fewer parents may have access to computers and the Internet either at work or at home. Existing access to technology, then, is both a condition for using services like myschoolonline.com, and a barrier to those who do not have access. Companies like Learning Network depend on their users' basic technology access, as well as their basic proficiency with getting online and navigating the Internet.

Two of the schools that were part of our case study could rely on parents' having good access to computers and the Internet. As a new housing development, Las Flores is in the rare position of having every home wired for the Internet. Parents are technologically savvy, and the teacher has been able to use their Web and e-mail proficiency to involve parents in their children's learning. Although St. Catherine's also reported a high level of parent involvement and connectivity, not every student has access to the Internet from home. Teachers at St. Catherine's provide extra time in the classroom for students to access Web resources they might need if they do not have access at home. Teachers reported that structured Web resources enabled more students to complete computer-based assignments at home, effectively extending the number of computers available to students for assignments.

The English teacher in San Francisco we interviewed reported that she could not count on parents' ability to access the school's Web sites, so their impact on parent involvement was limited. She reported that many parents lacked e-mail addresses and regular access to computers. Although she acknowledged the importance for low-income schools to be represented on the Web, she described her concern that reliance on a class Web site served to magnify inequalities in her classroom. Families without computers were not afforded equal opportunity to appreciate students' work or use online resources such as encyclopedias that improve students' ability to do research. Even students with Internet access often had to share one computer with the whole family, so they could not count on access when they needed it. To enable all students to see their work online, she had her Web site set as the home page on the two computers in her classroom.

How myschoolonline.com Is Used

Teachers interviewed reported using myschoolonline to build a sense of community beyond the classroom and to strengthen communication between home and school. Primary activities included announcing school events and student assignments, displaying and rewarding high-quality student work, organizing resources for student assignments and research, posting information and resources of interests to parents, and providing fun extracurricular activities for students. In addition to providing resources for home use, several teachers reported using the Web sites to organize teaching and learning in their classrooms. By listing links to encyclopedia resources and previewing useful Web pages on their classroom sites, teachers save valuable class time that often would be spent hunting for resources on their own.

Both the program coordinator at St. Catherine school and the teacher at Las Flores said they believe that posting student work on classroom Web sites has helped families and students talk about schoolwork and has increased teacher communication with parents overall. The St. Catherine's coordinator explained that when student work is posted on class Web sites, students often e-mail relatives in the Philippines to share their work. Teachers there and at Las Flores remarked that parents often show co-workers their students' poems and artwork on the Web. Students are thrilled to get immediate feedback from parents and friends congratulating them. The teacher at Las Flores had initially expected her class Web site to be more like a simple billboard; instead, it has become the centerpiece around which parents and students discussed learning. When a child has done excellent work, the teacher will post it to the Web and e-mail parents to invite them to look at their child's work. Providing students time in class to e-mail their parents means that as a teacher she is in on the "dinner table" conversation that normally would happen outside the walls of the school. When students are out sick, they are enthusiastic about receiving e-mail from their teacher.

How Web sites are used at home is more difficult to assess. Neither the teacher at Las Flores nor the teacher at the school in San Francisco counted "hits" on their sites. The coordinator for the St. Catherine myschoolonline site reported approximately 500 hits per week, or about 100 hits per day, on the school Web site–significant considering that the school is quite small, serving 340 students from 280 families. The teacher reported that although they also keep “reminder binders,” parents tell her that “students prefer to use the Web page to look up assignments, check their spelling lists, view the class calendar, and keep up with the names on the award lists. The award sections are the most important to the students. They like to see their names online, even if it’s only their first name.”

Maintenance and Technical Support

Teachers overall were very happy with myschoolonline’s technical support, reporting that the tutorials were easy to understand and that their questions were answered promptly and thoroughly via e-mail. Ms. Emory commented that myschoolonline staff encouraged her to give feedback on the service and had maintained communication with her over time.

One advantage that commercial education providers like Learning Network emphasize for products like myschoolonline.com is that the burden of maintaining servers and keeping the Web sites up is on the companies, rather than on individual teachers, schools, or districts. Companies provide space on their servers to schools, sometimes for free and sometimes at cost to the school, and the companies maintain the sites. Teachers and schools are responsible for developing and updating content to keep their sites current.

Preparing Teachers to Use myschoolonline.com

Although the teachers interviewed had some training in computer technology, they said they had learned to use myschoolonline.com from technology-proficient peers and by using the online tutorials and e-mail technical support. Two 8th grade teachers began using the service at St. Catherine school and introduced it to others as the word spread. The teacher at Las Flores reported that teachers in her school are interested in technology, and that teachers are offered both one-to-one training in the classroom and district-level trainings that focus on professional development to meet the district technology standards. Her school has not offered specific training on myschoolonline or any other Web development tool. Since she started her Web site, four other teachers at her school also have developed classroom sites.

Although the teachers at Las Flores and in San Francisco were both Internet savvy and experienced computer users, they were new to Web development and initially were intimidated by the prospects of having to learn how to write in HTML, the programming language used to develop Web sites. But the teacher at Las Flores indicated that she was ultimately surprised by how easy it was to put up a Web site. The templates made it less intimidating, and she wanted to learn more. Frustrated by the linear format of myschoolonline's templates, she decided to learn HTML so that she could build more complex pages after admiring other teachers' pages that use tables and frames to organize information.

Preparing Parents to Use the Software

With simple Web browsing skills, parents are able to access myschoolonline's services and their children's classroom Web sites. The schools we visited did not offer parent training in using computer technology.

Challenges to Sustaining the Program

Teachers reported that insufficient time and limited home connectivity were both factors limiting the usefulness of their Web sites. Because not all students have Internet access at home, teachers must duplicate Web resources in print form. Rather than saving them time, the Web site can become an additional burden.

The teacher at Las Flores described her frustration at not being able to maintain her site at the level that she would like. "I was good for the first half of the year, but then things began to pile up." She explained that if the site is not updated regularly, parents lose interest and stop visiting. Time is not structured in for her to work on it, so it becomes an additional responsibility and takes up her personal time. Although she tried to involve parent volunteers in the design and updating of her site, the logistics became too difficult.

St. Catherine school has developed some techniques to mitigate this issue. Whereas the teachers at Las Flores and in San Francisco design and maintain their classroom Web sites by themselves, many of St. Catherine's teachers give students permission to log in and edit their own work online. This practice not only saves teachers from having to type in student work, it also gives students an opportunity to learn valuable technology skills.

Discussion: Common Issues across the Cases

Though these cases represent three different ways that schools and districts have attempted to use technology to link home and school more closely, whether to improve student learning or increase parent involvement and communication with teachers, there are issues common to the three cases presented here that point to what is likely to make for best practice in the future in this area. First, teachers in each program have appropriated the technology for uses that reflect their diverse classrooms. Second, the programs have all struggled—and had varying degrees of success— with addressing inequities of technology at home and the impact of those inequities on program implementation. Third, all have paid close attention to the need for teacher training but have been less focused on preparing parents to use technology. Fourth, all struggle with issues related to sustainability, scalability, and replicability.

Although program designers typically have one or two goals for their programs, teachers' goals reflect the diversity of their school contexts and the students they serve. In Beaufort, for example, some teachers use laptops to support writing skill development, while others focus much more on teaching students how to use the Internet for research. Although Lightspan *Achieve Now* includes software that covers a wide range of subject matter, Blackfoot has chosen to focus primarily on literacy development, a key goal for that district. And for teachers using myschoolonline.com, teachers' goals for setting up school Web sites vary by their sense of how many of their children's parents have access to a computer and the Internet at home.

Equity of access is a concern that is at the forefront for each of the schools we visited as part of our case study research. Indeed, many were motivated to adopt these programs by a desire to improve computer access for students who are least likely to already have access to technology at home. Of the three program types we studied, however, only laptop programs provide that access directly. Both Lightspan's and Learning Network's products depend on some kind of technology access at home to be successful. As a result, they are likely to work best when the technology they require—whether a television set, a Sony PlayStation, or a computer connected to the Internet—is already available to students at home.

All the programs we studied provided extensive training to teachers. In Beaufort, the district has adopted a "three-tier" approach to preparing teachers to use technology in their teaching, moving from basic proficiency to curricular integration. In Blackfoot, teachers have all been trained not just how to use Lightspan software to supplement literacy instruction but also how to use the product's Internet features, assessment system, and parent surveys. And at St. Catherine school, teachers were able to rely on lots of informal support from technology-savvy peers to learn how to use myschoolonline.com software to build class Web sites.

Parent training across the sites was far less intensive. Both Beaufort and Blackfoot offered "introductory" sessions to parents but have not provided more extensive training in how to engage in joint activities with technology or to become more involved in their students' learning with technology. None of the schools with whom we spoke about myschoolonline.com provided parent training. Moreover, knowledge of how parents responded to and used technology with their children at home is limited across the programs, as it is in the published research on all the programs reviewed. What constitutes best practice in implementing the home component of these home-school links programs, then, remains largely unknown at this time.

Sustainability, Scalability, and Replicability of Programs

As programs that use technology to link home and school become more popular, it will be increasingly important for researchers to examine questions related to the sustainability, scalability, and replicability of programs. Sustainability pertains to the degree to which a program can secure and maintain the human, financial, and technical resources for its needs over time. Scalability refers to the ability to grow a program that may have begun as a pilot in one classroom or school to a group of schools, a district, or even an entire state. Replicability refers to the ability of a program to make explicit and test its understandings of what program features contribute to positive outcomes for students and their families. The issues of scalability and replicability, in practice, are not distinct, and how they are addressed depends on how programs meet their challenges, especially ones arising from changes in program finances or public policy.

Each of the programs we have studied has struggled with how to pay for new technologies, how to sustain interest in the program over time, and how to scale up a successful pilot. But for each of these programs, answers to questions about sustainability remain unclear. Beaufort is struggling to maintain subsidies for low-income students and maintain motivation among students who have grown accustomed to expecting new laptops when they come to middle school. Blackfoot's Family Technology Centers' funding ends in 2002, and program implementation varies significantly between the two sites. Schools that rely on commercial education vendors for Web site development tools are dependent on the uncertainties of the marketplace and the survival of commercial vendors themselves. More research on programs' strategies for sustainability, replicability, and scalability is needed as this area of educational technology continues to grow.

Conclusions and Study Implications

The knowledge base on the effectiveness of programs that use technology to support improved links between home and school is small. Only 19 studies were found that examined parent or student outcomes and that relied on experimental or quasi-experimental designs to test claims of their effectiveness. Moreover, the research designs used in many of the studies that have been conducted do not permit one to draw conclusions about whether students' and parents' participation in such programs actually *causes* changes in educational outcomes. Just 2 of the 19 studies in this review used experimental designs, and 7 studies did not provide any form of statistical controls to match treatment and comparison groups. The findings of six study authors who reported positive effects could not be aggregated or compared with the results of other studies because they did not include data needed to calculate effect sizes.

The decisions to exclude technical information related to mean scores, standard deviations, and numbers of study participants often were made consciously, in order to make reports more accessible to a lay audience. Decisions to exclude such data, however, may ultimately reduce the contribution of individual studies to policy-makers' and researchers' knowledge of the effectiveness of programs. Exclusion of such data makes it difficult to assess the validity of claims about individual studies. Individual study results are important when particular program features are unique to a site, as they are in a number of cases we reviewed (e.g., Project Hiller). In addition, not being able to draw conclusions about a single study also reduces the ability to ascertain patterns over multiple studies. Quantitative approaches to the synthesis of research findings depend on building an understanding of the effects of particular types of programs on the basis of prior studies. If no effect sizes can be calculated for a study, that study cannot contribute as much to policy-makers' or researchers' knowledge, and it becomes difficult to evaluate competing claims about whether or to what degree a program is effective.

Another limitation of the currently available research is that the evaluation studies reviewed do not provide evidence for *why* particular results were obtained. In some cases, researchers have presented information suggesting that technology was not in fact the primary lever of change (e.g., Light et al., 2001), but most have simply speculated about the reasons why technology might have benefits for growth of students' skills in reading, writing, and mathematics. Such data concerning the mechanisms through which impacts are achieved are of central importance to a deeper understanding of the short- and long-term impacts of educational technology (Norris et al., 1999).

Despite the limitations of many of the studies, we do believe their reported findings can be considered in designing future research studies of programs' effectiveness. In the 13 studies that met the methodological criteria for inclusion in the review and reported data needed to calculate effect sizes, positive associations reported between program participation and achievement in mathematics and writing, as well as reported effects of programs on technology proficiency and parent-school communication, appear sufficiently promising to warrant further investigation. The reported effects in these areas were comparable in magnitude to effects reported for class size reduction in two domains (mathematics and parent-school communication) and comparable to the effects of computer-assisted instruction in one other domain (writing). However, of the studies that examined the mathematics and parent-school communication outcomes, as many programs showed no effects as showed positive effects.

The positive associations between program participation and achievement were highest in programs that were embedded within larger reform initiatives. It may be that in these reform-embedded programs, technology augments and supports the school change process. It is possible to interpret the studies of laptop and desktop programs in a reform context as providing little evidence for the effectiveness of technology, but such an interpretation ignores the possible additive effects of technology in the reform process. Most reforms rely on multiple strategies; these strategies are all expected to build toward a common goal, such as improving equity or promoting student achievement. It may be that technology contributes toward the goals of a larger reform process.

In general, knowledge of the effects of new technologies on parent outcomes is particularly weak. In part, the reason why so little is known is that many programs aimed at helping to link parents more closely with schools, such as Web-hosting services, are just now scaling up and becoming popular. But perhaps more significant is that few studies have examined parent involvement or parent-school communication outcomes with an experimental or quasi-experimental design. Although survey and self-report data included in the studies in this synthesis suggest that there may be positive effects of programs with respect to parent outcomes, more empirical research is needed to validate these claims.

Fan and Chen (2001) note that the large majority of studies that have examined parent involvement are qualitative in nature and lack empirical data. In fact, much less is known about parent involvement than is often assumed, in part because previous research in this area has not defined parent involvement consistently, isolated the effects of parent involvement within interventions, or used objective measures of parent involvement (Baker & Soden, 1998). There is a need for a common framework (e.g., Epstein, 1994) to guide future research efforts.

Researchers in this domain could improve the knowledge base on technology-supported programs designed to improve the links between home and school by aligning their practice with emerging standards for reporting data in social science research. The American Psychological Association (1994), for example, recommends the use of effect size reporting in its peer-reviewed journals. Thompson (1998) has argued forcefully for the importance of effect size data in determining the educational significance of findings, suggesting that these data are more valuable than significance testing for comparing results across studies (cf. Robinson & Levin, 1997). To be sure, it may be of value to report both *p*-values and effect sizes in all studies, even if it means reporting such data in an appendix, so that other researchers can use the data to summarize results across findings.

In addition to the need for more rigorous designs and reporting practices, additional research is needed in two areas to advance understanding of these kinds of programs. First, there is a need for more research on the cost-effectiveness of programs. Laptop programs especially remain costly for schools and districts to undertake; indeed, cost remains the top barrier to implementation of laptop programs, according to computer industry officials. The cost of laptops has forced programs like Beaufort's to consider ending subsidies for low-income students to prevent the debt incurred by the program from spiraling. More research is needed as to the cost per pupil of laptop programs, and whether low-cost alternatives to desktop and laptop computers might result in just as large gains in achievement. Some of these low-cost alternatives, such as handheld computers, are becoming widely available to schools today; others are yet to be developed. Researchers will need to provide better data to policy-makers than are currently available to answer questions about whether alternative strategies are better for improving equity of access and getting better results.

Second, future research undertaken to explain the impacts of technology designed to link home and school should focus more explicitly on understanding the dynamics of technology use at home. Some studies (e.g., Kiesler, et al., 1999) have examined closely how the dynamics of home computer use affect family dynamics and the development and distribution of technology proficiency within families. More studies of the program types included in this synthesis could contribute to a better knowledge base for drawing conclusions about parent involvement in the learning process and factors in the home that contribute to better parent-school communication. They also may be able to speak to the differential impact of programs that provide or enhance technology access, compared with programs that rely on the availability of access to computers and the Internet at home, something the current study was not able to distinguish through the research synthesis or case study research.

The vision for improving educational opportunities to learn with technology by linking home and school more closely is one to which many schools and districts have a strong commitment. Many more schools and districts have planned programs like the ones we reviewed that will be implemented in the near future. To understand their likely impact better, we will need more studies that examine the broad range of impacts these programs might have, not just on students but also on parent-teacher and parent-child relationships. We will need better measures of these impacts and also better documentation of what kinds of program designs are most effective. Finally, we will need a shared commitment among researchers to report common outcome indicators, so that policy-makers, evaluators, and the public can clearly understand the impact of educational technology programs that bridge home and school.

References

Allen, A. A., & Mountain, L. (1992). When inner city black children go online at home. *Computing Teacher, 20,* 35-37.

American Psychological Association. (1994). *Publication manual of the American Psychological Association* (4th edition). Washington, DC: Author.

Anderson, R. E., & Becker, H. J. (2001). *School investments in instructional technology.* Irvine, CA, and Minneapolis, MN: Center for Research on Information Technology and Organizations, University of California, Irvine, and University of Minnesota. Available online at: http://www.crito.uci.edu/tlc/findings/report_8/startpage.htm. [Accessed 9/2/01]

Aschbacher, P. R. (1999). *Developing indicators of classroom practice to monitor and support school reform.* CSE Technical Report 513. Los Angeles, CA: National Center for Research on Evaluation, Standards, and Student Testing.

Baker, A. J. L., & Soden, L. M. (1998). *The challenges of parent involvement research.* ERIC/CUE Digest No. 134. Available at: http://www.ed.gov/databases/ERIC_Digests/ed419030.html. [Accessed 7/25/01]

Baker, E. (1999, July). *Technology: How do we know it works?* Paper presented at the Secretary's Conference on Educational Technology. Available online at: http://www.ed.gov/Technology/TechConf/1999/whitepapers/paper5.html. [Accessed 8/30/01].

Bauch, J. (1994, November). *Voice-based technology for parent involvement.* Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Nashville, TN.

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

Becker, H. J., & Anderson, R. (2000). *Subject and teacher objectives for computer-using classes by school socio-economic status.* Irvine, CA, and Minneapolis, MN: Center for Research on Information Technology and Organizations, University of California, Irvine, and University of Minnesota. Available online at: http://www.crito.uci.edu/tlc/findings/snapshot7/. [Accessed 9/2/01]

Blanchard, J. (1997, November). *The family-school connection and technology.* Paper presented at the Families, Technology, and Education Conference, Washington, DC.

Boruch, R., Petrosino, A., & Chalmers, I. (1999, July). *The Campbell Collaboration: A proposal for systematic, multi-national, and continuous reviews of evidence.* Paper for the First Meeting of the Campbell Collaboration, University College, London, England.

Cameron, C. A., & Lee, K. (1997). Bridging the gap between home and school with voicemail technology. *The Journal of Educational Research, 90,* 182-190.

Camilli, G., & Bulkley, K. (2001). Critique of "An evaluation of the Florida A-Plus Accountability and School Choice Program." *Education Policy Analysis Archives, 9,* 1-10. Available online at http://epaa.asu.edu/epaa/v9n7. [Accessed 7/15/01]

Chang, H.-H., Henriquez, A., Honey, M., Light, D., Moeller, B., & Ross, N. (1998). *The Union City story: Education reform and technology students' performance on standardized tests.* New York: Center for Children and Technology.

Chiaramonte, J. (1999, April/May). The 1998 Roper Youth Report. New York: Roper Starch Worldwide.

Clarke, M., & Oxman, A. D. (Eds). (2001). *Cochrane reviewers' handbook 4.1.2* [Updated March 2001]. In Cochrane Library, Issue 2. Oxford, England: Update Software.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design and analysis issues for field settings.* Boston: Houghton Mifflin.

Cordray, D. S. & Fischer, R. (1994). Synthesizing evaluation findings. In J. Wholey, H. Hary, & K. Newcomer (Eds.), *Handbook of practical evaluation* (pp. 198-231). San Francisco: Jossey-Bass.

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 classrooms, 1980-2000.* Cambridge, MA: Harvard University Press.

Dickersin, K., Min, K., & Meinert, C. L. (1992). Factors influencing publication of research results. *Journal of the American Medical Association, 267,* 374-378.

Education Commission of the States. (2000). *Smart desktops for teachers.* Denver, CO: Author.

Epstein, J. (1994). Theory to practice: School and family partnerships lead to school improvement and student success. In C. L. Fagnano & B. Z. Werber (Eds.), *School, family, and community interaction: A view from the firing lines* (pp. 39-52). Boulder, Co: Westview.

Fan, X., & Chen, M. (2001). Parental involvement and students' academic achievement: A meta-analysis. *Educational Psychology Review, 12*, 1-22.

Funkhouser, J. E., Stief, E. A., & Allen, S. E. (1998). *Title I school-parent compacts: Supporting partnerships to improve learning. Final report.* Washington, DC: Policy Studies Associates.

Giacquinta, J. B., Bauer, J., & Levin, J. E. (1993). *Beyond technology's promise: An examination of children's educational computing at home.* Cambridge, England: Cambridge University Press.

Glass, G. V., McGraw, B., & Smith, M. L. (1981). *Meta-analysis in social research.* Beverly Hills, CA: Sage.

Goldenberg, C. N. (1987). Low income Hispanic parents' contributions to their first-grade children's word-recognition skills. *Anthropology and Education Quarterly, 18,* 147-179.

Gwaltney, L. (2000). *Year three final report the Lightspan Partnership, Inc. Achieve Now Project: Unified School District 259, Wichita Public Schools.* Wichita, KS: Allied Educational Research and Development Services.

Gwaltney, L. (1999). *Year two interim report the Lightspan Partnership, Inc. Achieve Now Project: Unified School District 259, Wichita Public Schools.* Wichita, KS: Allied Educational Research and Development Services.

Gwaltney, L. (1998). *Year one interim report the Lightspan Partnership, Inc. Achieve Now Project: Unified School District 259, Wichita Public Schools.* Wichita, KS: Author.

Hattie, J., Biggs, J., & Purdie, N. (1996). Effects of learning skills interventions on student learning: A meta-analysis. *Review of Educational Research, 66,* 99-136.

Haynes, C. (1996). *The effectiveness of using laptop computers with middle school students identified as being inhibited writers.* Unpublished doctoral dissertation. Cincinnati: Union Institute.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis.* New York: Academic Press.

Jackson, G. B. (1980). Methods for integrative reviews. *Review of Educational Research, 50,* 438-460.

Keselman, H. J., Huberty, C. J., Lix, L. M., Olejnik, S., Cribbie, R., Donahue, B., Kowalchuk, R. K., Lowman, L. L., Petoskey, M. D., Keselman, J. C., & Levin, J. R. (1998). Statistical practices of educational researchers: An analysis of their ANOVA, MANOVA, and ANCOVA analyses. *Review of Educational Research, 68,* 350-386.

Kiesler, S., Lundmark, V., Zdaniuk, B., Kraut, R., Scherlis, W., & Mukhopadhyay, T. (1999, November). *Troubles with the Internet: The dynamics of help at home.* Pittsburgh, PA: Carnegie Mellon University.

Komoski, D. (2001). Using the digital divide to bridge other divides. Article published online for the Digital Divide Network [available at http://www.digitaldividenetwork.org/content/stories/index.cfm?key=145. [Accessed 8/24/01]

Kozma, R. (1991). Learning with media. *Review of Educational Research, 61,* 179-212.

Kulik, C. C., & Kulik, J. A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior, 7,* 75-94.

Kurth, R. (1987). Using word processing to enhance revision strategies during student writing activities. *Educational Technology, 27,* 13-19.

Lee, V., & Loeb, S. (1995). Where do Head Start attendees end up? One reason why preschool effects fade out. *Education, Evaluation and Policy Analysis, 17,* 148-168.

Levin, H., Glass, G.V., & Meister, G.R. (1986). The political arithmetic of cost-effectiveness analysis. *Phi Delta Kappan, 68*, 69-72.

Light, D., McDermott, M., & Honey, M. (2001, June). *Project Hiller: The impact of ubiquitous portable computing on an urban school.* Presentation at the National Educational Computing Conference, Chicago, IL.

Light, R. J., & Pillemer, D. B. (1984). *Summing up: The science of reviewing research.* Cambridge, MA: Harvard University Press.

Lipsey, M. (1990). *Design sensitivity: Statistical power for experimental research.* Thousand Oaks, CA: Sage.

Lowther, D., Ross, S., & Morrison, G. (2001, June). *Evaluation of a laptop program: Successes and recommendations.* Paper presented at the National Educational Computing Conference, Chicago, IL.

Marshall, C., & Rossman, G. (1995). *Designing qualitative research* (2nd ed.). Thousand Oaks, CA: Sage.

Means, B., & Olson, K. (1995). *Technology's role in education reform: Findings from a national study of innovating schools.* Menlo Park, CA: SRI International.

Metis Associates. (1999, April). *Program evaluation: The New York City Board of Education Community School District Six Laptop Project.* Paper presented at the Annual Meeting of the American Educational Research Association, Montreal, Quebec.

Myers, J. L. (1996). *The influence of a take-home computer program on mathematics achievement and attitudes of Title I elementary school children.* Unpublished doctoral dissertation. Athens, GA: University of Georgia.

National Center for Education Statistics (NCES). (2000). *Teachers' tools for the 21st century: A report on teachers' use of technology.* Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

National School Boards Association (NSBA). (2000). *Safe and smart: Research and guidelines for children's use of the Internet.* Washington, DC: Author.

National Telecommunications and Information Administration (NTIA). (1999). *Falling through the Net: Defining the digital divide.* Washington, DC: U.S. Department of Commerce.

National Telecommunications and Information Administration (NTIA). (2000). *Falling through the Net: Toward digital inclusion.* Washington, DC: U.S. Department of Commerce.

Norman, D. A. (1999). *Invisible computer: Why good products can fail, the personal computer is so complex and information appliances are the solution.* Cambridge, MA: MIT Press.

Norris, C., Smolka, J., & Soloway, E. (1999, August). *Convergent analysis: A method for extracting the value of research studies on technology in education.* Paper presented at the U.S. Department of Education Secretary's Conference on Educational Technology, Washington, DC. Available at: http://www.ed.gov/Technology/TechConf/1999/whitepapers/paper2.html. [Accessed 7/25/01]

North Carolina Department of Public Instruction. (1999). *1997-98 report of student performance: North Carolina Tests of Computer Skills.* Raleigh, NC: Author. Available at: http://www.ncpublicschools.org/accountability/testing/computerskills/compskills97-98.pdf. [Accessed 9/5/01]

Osher, D., & Snow, S. (1997). *Using technology to link families and schools to research-based information.* Paper presented at the Families, Technology, and Education Conference, Washington, DC.

Reinen, I. J., & Plomp, T. (1997). Information technology and gender equalit–A contradiction in terminis? *Computers & Education, 28*(2), 65-78.

Riccobono, J. A. (1986). *Use of electronic information technologies for non-school learning in American households: Report of findings from the 1985 Home Information Technology Study (HITS)* (CS-86-215). Washington, DC: U.S. Department of Education, Center for Statistics.

Robinson, D., & Levin, J. (1997). Reflections on statistical and substantive significance, with a slice of replication. *Educational Researcher, 26,* 21-25.

Rockman ET AL (2000). *A more complex picture: Laptop use and impact in the context of changing home and school access.* San Francisco: Author.

Rockman ET AL (1998). *Powerful tools for schooling: Second year study of the laptop program.* San Francisco: Author.

Rockman ET AL. (1995). *Assessing the growth: The Buddy Project evaluation, 1994-5.* San Francisco: Author.

Rocheleau, B. (1995). Computer use by school-age children: Trends, patterns, and predictors. *Journal of Educational Computing Research, 12,*1-17.

Rogers, E. M. (1995). *Diffusion of innovations.* New York: Free Press.

Rosenthal, R. (1994). Parametric measures of effect size. In H. Cooper & L. V. Hedges (Eds.), *The handbook of research synthesis* (pp. 231-244). New York: Russell Sage Foundation.

Russell, M. (1999). Testing on computers: A follow-up study comparing performance on computer and on paper. *Education Policy Analysis Archives 7* (3). Available online at: http://epaa.asu.edu/epaa/v7n20/. [Accessed 8/30/01]

Russell, M., & Haney, W. (1997). Testing writing on computers: An experiment comparing student performance on tests conducted via computer and via paper-and-pencil. *Education Policy Analysis Archives, 5*(3). Available online at http://epaa.asu.edu/epaa/v5n3.html. [Accessed 8/31/01]

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms.* New York: Teachers College Press.

Schaumburg, H. (2001, June). *Fostering girls' computer literacy through laptop learning.* Paper presented at the National Educational Computing Conference, Chicago, IL.

Schieber, C. E. (1999). *Information technology and education: An evaluation of a school laptop computer program.* Unpublished doctoral dissertation. Seattle, WA: Seattle Pacific University.

Scott-Jones, D. (1987). Mother-as-teacher in the families of high- and low-achieving low-income black first graders. *Journal of Negro Education, 56,* 21-34.

Selwyn, N. (1998). The effect of using a home computer on students' educational use of IT. *Computers & Education, 31*(2), 211-227.

Shakeshaft, C., Mann, D., & Becker, J. (1999). *Lightspan* Achieve Now! *Documenting the second year of educational achievement and program effects in the schools of the Adams County School District 50, Westminster, Colorado.* Huntington, NY: Interactive, Inc.

Siegle, D., & Foster, T. (2000, April). *Effects of laptop computers with multimedia and presentation software on student achievement.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Slavin, R. (1986). Best-evidence synthesis: An alternative to meta-analysis and traditional reviews. *Educational Researcher, 15*(9), 5-11.

Snow, C., Barnes, W., Chandler, J., Goodman, I., & Hemphill, L. (1991). *Unfulfilled expectations: Home and school influences on literacy.* Cambridge, MA: Harvard University Press.

Sparks, J. A. (1986). *The effect of microcomputers in the home on computer literacy test scores.* Unpublished dissertation. Central Missouri State University.

Stearns, M. S., & Peterson, S. (1973). *Parent involvement in compensatory education programs: Definitions and findings.* Washington, DC: Office of Education, Department of Health, Education, and Welfare.

Stevenson, K. R. (1998). *Evaluation report - Year 2: Middle School Laptop Program, Beaufort County School District.* Beaufort, SC: Beaufort County School District.

Stevenson, K. R. (1999). *Evaluation report - Year 3: Middle School Laptop Program, Beaufort County School District.* Beaufort, SC: Beaufort County School District.

Stock, W. A., Okun, M., Haring, M., Miller, W., Kenney, C., & Ceurvorst, R. (1982). Rigor in data synthesis: A case study of reliability in meta-analysis. *Educational Researcher, 11*, (6)10-14.

Stock, W. A. (1994). Systematic coding for research synthesis. In H. Cooper & L. V. Hedges (Eds.), *The handbook of research synthesis* (pp. 125-162). New York: Russell Sage Foundation.

Thomas, P. G., & Rickhuss, M. G. (1992). An experiment in the use of computer algebra in the classroom. *Education and Computing, 8,* 255-263.

Thompson, B. (1998). Statistical significance and effect size reporting: Portrait of a possible future. *Research in the Schools, 5,* 33-38.

Tizard, J., Schofield, W., & Hewison, J. (1982). Collaboration between teachers and parents in assisting children's reading. *British Journal of Educational Psychology, 52,* 1-15. (EJ 264 773)

U.S. Census Bureau (1999, September). *Computer use in the United States: October 1997*. Washington, DC: Author. Available at: http://www.census.gov/population/www/socdemo/computer.html [Accessed 9/7/01]

U.S. Census Bureau (2001, September). *Home computers and Internet use in the United States: August 2000*. Washington, DC: Author. Available at: http://www.census.gov/population/ www/socdemo/computer.html [Accessed 9/7/01]

U.S. General Accounting Office. (1992, March). *The evaluation synthesis.* Washington, DC: U.S. Author.

Valdez, M. N., Foertsch, M., Anderson, M., Hawkes, M., & Raack, L. (2000). *Computer-based technology and learning: Evolving uses and expectations.* Naperville, IL: North Central Regional Educational Laboratory. Available online at: http://www.ncrel.org/tplan/cbtl/toc.htm. [Accessed 8/30/01]

Walsh, M. (2001, February 21). Pearson hopes to “widen the definition of education.” *Education Week, 20*(8), 23.

Wenglinsky, H. (1998). *Does it compute? The relationship between educational technology and student achievement in mathematics.* Princeton, NJ: Educational Testing Service.

Wortman, P. (1994). Judging research quality. In H. Cooper & L. V. Hedges (Eds.), *The handbook of research synthesis* (pp. 97-109). New York: Russell Sage Foundation.

Outcome Studies Included in the Research Synthesis

Laptop Programs

Cross-Curricular Programs

Lowther, D., Ross, S., & Morrison, G. (2001, June). *Evaluation of a laptop program: Successes and recommendations.* Paper presented at the National Educational Computing Conference, Chicago, IL.

Metis Associates. (1999, April). *Program evaluation: The New York City Board of Education Community School District Six Laptop Project.* Paper presented at the Annual Meeting of the American Educational Research Association, Montreal, Quebec.

Rockman et al. (2000). *A more complex picture: Laptop use and impact in the context of changing home and school access.* San Francisco: Author.

Rockman et al. (1998). *Powerful tools for schooling: Second year study of the laptop program.* San Francisco: Author.

Schaumburg, H. (2001, June). *Fostering girls' computer literacy through laptop learning.* Paper presented at the National Educational Computing Conference, Chicago, IL.

Schieber, C. E. (1999). *Information technology and education: An evaluation of a school laptop computer program.* Unpublished doctoral dissertation. Seattle, WA: Seattle Pacific University.

Stevenson, K. R. (1999). *Evaluation report - Year 3: Middle School Laptop Program, Beaufort County School District.* Beaufort, SC: Beaufort County School District.

Stevenson, K. R. (1998). *Evaluation report - Year 2: Middle School Laptop Program, Beaufort County School District.* Beaufort, SC: Beaufort County School District.

Subject-Matter-Specific Programs

Haynes, C. (1996). *The effectiveness of using laptop computers with middle school students identified as being inhibited writers.* Unpublished doctoral dissertation. Cincinnati: Union Institute.

Myers, J. L. (1996). *The influence of a take-home computer program on mathematics achievement and attitudes of Title I elementary school children.* Unpublished doctoral dissertation. Athens, GA: University of Georgia.

Siegle, D., & Foster, T. (2000, April). *Effects of laptop computers with multimedia and presentation software on student achievement.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Reform-Embedded Program

Light, D., McDermott, M., & Honey, M. (2001, June). *Project Hiller: The impact of ubiquitous portable computing on an urban school.* Presentation at the National Educational Computing Conference, Chicago, IL.

Home Desktop Programs

Chang, H.-H., Henriquez, A., Honey, M., Light, D., Moeller, B., & Ross, N. (1998). *The Union City story: Education reform and technology students' performance on standardized tests.* New York: Center for Children and Technology.

Rockman et al. (1995). *Assessing the growth: The Buddy Project evaluation, 1994-5.* San Francisco: Author.

Discrete Educational Software (with parent/home component)

Gwaltney, L. (2000). *Year three final report the Lightspan Partnership, Inc. Achieve Now Project: Unified School District 259, Wichita Public Schools.* Wichita, KS: Allied Educational Research and Development Services.

Gwaltney, L. (1999). *Year two interim report the Lightspan Partnership, Inc. Achieve Now Project: Unified School District 259, Wichita Public Schools.* Wichita, KS: Allied Educational Research and Development Services.

Gwaltney, L. (1998). *Year one interim report the Lightspan Partnership, Inc. Achieve Now Project: Unified School District 259, Wichita Public Schools.* Wichita, KS: Author.

Shakeshaft, C., Mann, D., & Becker, J. (1999). *Lightspan* Achieve Now! *Documenting the second year of educational achievement and program effects in the schools of the Adams County School District 50, Westminster, Colorado.* Huntington, NY: Interactive, Inc.

Voicemail Programs

Cameron, C. A., & Lee, K. (1997). Bridging the gap between home and school with voicemail technology. *The Journal of Educational Research, 90*, 182-190.

APPENDIX A

Educational Organizations and Types of Studies Sought

American Association of School Administrators
Topics: technology supports for improved home-school communication, technology supports for parental involvement in student learning, technology supports for increasing student engagement in learning, improving home access to technology
Years: 1995-2000
Types of documents: reports, evaluation studies

Council of the Great City Schools
Topics: district-sponsored initiatives aimed at increasing home access to technology for students and parents
Years: 1995-2000
Types of documents: reports, evaluation studies

International Society for Technology in Education (ISTE)
Topics: technology supports for improved home-school communication, technology supports for parental involvement in student learning, technology supports for increasing student engagement in learning, improving home access to technology
Years: 1995-2000
Types of documents: policy documents, reports, evaluation studies

National School Boards Association (NSBA)
Topics: NSBA-sponsored initiatives aimed at increasing home access to technology for students and parents
Years: 1996-2000
Types of documents: evaluation reports

Milken Exchange on Educational Technology
Topics: technology supports for improved home-school communication, technology supports for parental involvement in student learning, technology supports for increasing student engagement in learning, improving home access to technology
Years: 1997-2000
Types of documents: policy documents, reports, evaluation studies

Center for Research on Information Technology
Topics: technology supports for improved home-school communication, technology supports for parental involvement in student learning, technology supports for increasing student engagement in learning, improving home access to technology
Years: 1995-2000
Types of documents: unpublished manuscripts, evaluation studies

Center for Technology in Education, Bank Street College
Topics: technology supports for improved home-school communication, technology supports for parental involvement in student learning, technology supports for increasing student engagement in learning, improving home access to technology
Years: 1995-2000
Types of documents: unpublished manuscripts, evaluation studies

R*TECs (High Plains, Mid-Atlantic, North Central, NE and Islands, Appalachian, South Central, WestEd)
Topics: technology supports for improved home-school communication, technology supports for parental involvement in student learning, technology supports for increasing student engagement in learning, improving home access to technology
Years: 1997-2000
Types of documents: summaries of research on the topics, evaluation studies

State Educational Officers
Topics: TCLF-funded initiatives aimed at improvi ng links between home and school
Years: 1995-2000
Types of documents: evaluation reports, studies of implementation, policy briefs

APPENDIX B

Advance Organizer: Reading and Reviewing Research Studies for Synthesis

First Read

- Reading for basic claims and evidence
- Coming to an understanding about the purpose of the study
- Appreciating differences between study purpose and SRI task purpose

Database Elements:	Purpose/Focus/Research Questions What type of study is this? What are the students doing with the software? What special preparation have teachers been given for the experiments, if any? What student outcomes are being measured, and how? What did the author(s) conclude from the study (verbatim)?

Second Read

- Reading for details
- Understanding the methodological sophistication of the study
- Analyzing strengths and weaknesses of the study

Database Elements:	Details of setting (grade level, scope/location, subject matter, school descriptions) Details of data collection (e.g., who is teaching, how study was designed, data collection methods) Details of the sample (e.g., study groups description) Details of technology used (e.g., hardware, software) Details of implementation (nature of treatment, non-technology components) Details of quantitative analysis (e.g., methods used, control procedures used) Analysis of strengths and limitations (from author, from reader) Selection of keywords

APPENDIX C

Coding Guide

Sent as a separate document.

APPENDIX D

Case Study Protocols

Sent as a separate document.

APPENDIX E

Home-School Links Programs and Reading Achievement Effect Sizes

Study	Indicator(s)	*N*	*d* (effect size)	95% Confidence Interval	
				Lower Limit	Upper Limit
Laptop Programs					
Light, McDermott, & Honey (2001)	HSPT Reading Scores (district test) (10th)	39	+1.26	+0.57	+1.95
Stevenson (1998)	MAT7 NCErr* (8th)	1162	+0.10	-0.05	+0.24
Home Desktop Programs					
Chang et al. (1998)	Early Warning Reading Test (district test) Year 1/7th Grade Cohort	226	+0.16	-0.10	+0.42
Chang et al. (1998)	Early Warning Reading Test (district test) Year 2/8th Grade	249	+0.02	-0.23	+0.27
Chang et al. (1998)	Early Warning Reading Test (district test) Year 2/7th Grade Cohort	186	+0.21	-0.07	+0.50
Chang et al. (1998)	Early Warning Reading Test (district test) Year 3/9th Grade	190	+0.16	-0.12	+0.44
Chang et al. (1998)	Early Warning Reading Test (district test) Year 3/7th Grade Cohort	142	+0.20	-0.13	+0.52
Chang et al. (1998)	Early Warning Reading Test (district test) Year 4/10th Grade	126	+0.02	-0.33	+0.37
Discrete Software Programs					
Gwaltney (1998)	MAT7 Reading (3rd)	349	+0.07	-0.14	+0.28
Gwaltney (1998)	MAT7 Reading (4th)	358	+0.04	-0.17	+0.24
Gwaltney (1998)	MAT7 Reading (5th)	320	+0.07	-0.15	+0.29
Gwaltney (1999)	MAT7 Reading (3rd)	368	+0.01	-0.19	+0.21
Gwaltney (1999)	MAT7 Reading (4th)	259	+0.10	-0.15	+0.34
Gwaltney (1999)	MAT7 Reading (5th)	274	+0.06	-0.18	+0.29
Gwaltney (2000)	MAT7 Reading (4th)	302	+0.32	+0.08	+0.56
Gwaltney (2000)	MAT7 Reading (5th)	190	-0.08	-0.37	+0.20

*NCErr is a composite score that includes reading and mathematics achievement levels. Stevenson (1998) did not report data on subscales of the MAT7.

APPENDIX F

Home-School Links Programs and Math Achievement Effect Sizes

Study	Indicator(s)	*N*	*d* (effect size)	95% Confidence Interval Lower Limit	95% Confidence Interval Upper Limit
Laptop Programs					
Light, McDermott, & Honey (2001)	HSPT Math Scores (district test) (10th)	39	+0.94	+0.27	+1.60
Stevenson (1998)	MAT7 NCErr* (8th)	1162	+0.10	-0.05	+0.24
Myers (1996)	Multiplication Fact Test (3rd-5th)	109	-0.12	-0.50	+0.25
Myers (1996)	Division Fact Test (3rd-5th)	72	-0.04	-0.50	+0.42
Myers (1996)	Chapter Math Tests (Heath Math Connections series) (3rd-5th)	105	+0.12	-0.26	+0.50
Home Desktop Programs					
Chang et al. (1998)	Early Warning Math Test (district test) Year 1/7th Grade Cohort	226	+0.68	+0.41	+0.95
Chang et al. (1998)	Early Warning Math Test (district test) Year 2/8th Grade	249	+0.18	-0.07	+0.43
Chang et al. (1998)	Early Warning Math Test (district test) Year 2/7th Grade Cohort	186	+0.37	+0.08	+0.66
Chang et al. (1998)	Early Warning Math Test (district test) Year 3/9th Grade	190	+0.34	+0.06	+0.63
Chang et al. (1998)	Early Warning Math Test (district test) Year 3/7th Grade Cohort	142	+0.39	+0.06	+0.72
Chang et al. (1998)	Early Warning Math Test (district test) Year 4/10th Grade	126	+0.74	+0.38	+1.10
Discrete Software Programs					
Gwaltney (1998)	MAT7 Math (3rd)	352	+0.29	+0.07	+0.50
Gwaltney (1998)	MAT7 Math (4th)	357	-0.04	-0.26	+0.16
Gwaltney (1998)	MAT7 Math (5th)	328	+0.09	-0.13	+0.31
Gwaltney (1999)	MAT7 Math (3rd)	370	-0.02	-0.22	+0.19
Gwaltney (1999)	MAT7 Math (4th)	255	+0.27	+0.02	+0.52
Gwaltney (1999)	MAT7 Math (5th)	272	+0.15	-0.09	+0.39
Gwaltney (2000)	MAT7 Math (4th)	236	+0.12	-0.14	+0.38
Gwaltney (2000)	MAT7 Math (5th)	185	-0.21	-0.50	+0.08

*NCErr is a composite score that includes reading and mathematics achievement levels. Stevenson (1998) did not report data on subscales of the MAT7.

APPENDIX G

Home-School Links Programs and Writing Achievement Effect Sizes

Study	Indicator(s)	*N*	*d* (effect size)	95% Confidence Interval Lower Limit	95% Confidence Interval Upper Limit
Laptop Programs					
Light, McDermott, & Honey (2001)	HSPT Writing Scores (district test) (10th)	39	+0.67	+0.03	+1.32
Schieber (1999)	6-Trait Writing Assessment (Ideas) (5th-6th)	460	+0.10	-0.08	+0.28
Schieber (1999)	6-Trait Writing Assessment (Organization) (5th-6th)	460	-0.02	-0.21	+0.16
Schieber (1999)	6-Trait Writing Assessment (Voice) (5th-6th)	460	+0.14	-0.04	+0.32
Schieber (1999)	6-Trait Writing Assessment (Words) (5th-6th)	460	+0.22	+0.04	+0.41
Schieber (1999)	6-Trait Writing Assessment (Fluency) (5th-6th)	460	+0.03	-0.15	+0.22
Schieber (1999)	6-Trait Writing Assessment (Conventions) (5th-6th)	460	+0.05	-0.14	+0.23
Haynes (1996)	Spelling (program-embedded assessment) (middle)	57	+0.11	-0.41	+0.60
Haynes (1996)	Capitalization (program-embedded assessment) (middle)	57	+0.07	-0.44	+0.60
Haynes (1996)	Punctuation (program-embedded assessment) (middle)	57	+0.61	+0.08	+1.14
Haynes (1996)	Sentence Problems (program-embedded assessment) (middle)	56	+0.38	-0.15	+0.90
Haynes (1996)	General Usage (program-embedded assessment) (middle)	57	+0.40	-0.13	+0.93
Haynes (1996)	Grammar (program-embedded assessment) (middle)	57	-0.02	-0.50	+0.54
Haynes (1996)	Style (program-embedded assessment) (middle)	57	+0.45	-0.08	+0.97
Haynes (1996)	Word Counts (program-embedded assessment) (middle)	57	-0.13	-0.65	+0.39
Haynes (1996)	Use of planning (middle)	57	+0.07	-0.44	+0.60
Haynes (1996)	Use of revising and editing (middle)	57	-0.02	-0.54	+0.50
Haynes (1996)	Extent of sharing of writing (middle)	57	+0.12	-0.40	+0.64
Lowther, Ross, & Morrison (2001)	WLCS Writing Test (district test) (5th-6th)	64	+0.25	-0.25	+0.74

APPENDIX G

Home-School Links Programs and Writing Achievement Effect Sizes

Home Desktop Programs					
Chang et al. (1998)	Early Warning Writing Test (district test) Year 1/7th Grade Cohort	226	+0.62	+0.35	+0.89
Chang et al. (1998)	Early Warning Writing Test (district test) Year 2/8th Grade	249	+0.20	-0.04	+0.45
Chang et al. (1998)	Early Warning Writing Test (district test) Year 2/7th Grade Cohort	186	+0.40	+0.11	+0.69
Chang et al. (1998)	Early Warning Writing Test (district test) Year 3/9th Grade	190	+0.50	-0.21	+0.79
Chang et al. (1998)	Early Warning Writing Test (district test) Year 3/7th Grade Cohort	142	+0.55	+0.22	+0.89
Chang et al. (1998)	Early Warning Writing Test (district test) Year 4/10th Grade	126	+0.06	-0.29	+0.41

APPENDIX H

Home-School Links Programs and Other Outcomes Effect Sizes

Study	Indicator(s)	*N*	*d* (*effect size*)	95% Confidence Interval Lower Limit	95% Confidence Interval Upper Limit
Laptop Programs					
Schaumburg (2001)	Computer Literacy	103	+1.17	+0.75	+1.60
Myers (1996)	Attitudes Toward Math	108	+0.12	-0.26	+0.50
Haynes (1996)	Attitudes Toward Writing	57	+0.38	-0.15	+0.91
Haynes (1996)	Value of Writing	57	+0.31	-0.22	+0.83
Siegle & Foster (2000)	GPA in Anatomy and Physiology (Study 1) (10th-11th)	27	+0.15	-0.61	+0.92
Siegle & Foster (2000)	GPA in Anatomy and Physiology (Study 2) (10th-11th)	27	+0.88	+0.07	+1.68
Discrete Software Programs					
Gwaltney (1998)	Peabody Picture Vocabulary Test (PPVT) (K)	183	+0.20	-0.09	+0.49
Gwaltney (1998)	Peabody Picture Vocabulary Test (PPVT) (1)	152	+0.13	-0.19	+0.45
Gwaltney (1998)	Peabody Picture Vocabulary Test (PPVT) (2)	147	+0.19	-0.15	+0.53

APPENDIX I

Home-School Links Programs and Effect Sizes for Low-Income Students

Study	Indicator(s)	*N*	*d* (effect size)	95% Confidence Interval	
				Lower Limit	Upper Limit
Laptop Programs					
Stevenson (1998)	MAT7 NCErr* (8th)	574	+0.67	+0.42	+0.92
Myers (1996)**	Multiplication Fact Test (3rd-5th)	109	-0.12	-0.50	+0.25
Myers (1996)	Division Fact Test (3rd-5th)	72	-0.04	-0.50	+0.42
Myers (1996)	Chapter Math Tests (Heath Math Connections series) (3rd-5th)	105	+0.12	-0.26	+0.50
Myers (1996)	Attitudes Toward Math (3rd-5th)	108	+0.12	-0.26	+0.50
Myers (1996)	Parent attitudes toward school and toward family involvement (3rd-5th)	70	-0.13	-0.29	+0.41
Myers (1996)	Strength of family-initiated learning activities and parent-school communication (3rd-5th)	68	-0.14	-0.62	+0.33
Myers (1996)	Strength of school-initiated learning activities and parent-school communication (3rd-5th)	68	+0.17	-0.30	+0.65
Discrete Software Programs					
Gwaltney (2000)	MAT7 Reading (4th)	223	+0.36	+0.10	+0.63
Gwaltney (2000)	MAT7 Reading (5th)	178	-0.18	-0.48	+0.11
Gwaltney (2000)	MAT7 Math (4th)	225	+0.13	-0.05	+0.48
Gwaltney (2000)	MAT7 Math (5th)	176	-0.32	-0.63	-0.03

*NCErr is a composite score that includes reading and mathematics achievement levels. Stevenson (1998) did not report data on subscales of the MAT7.

**Study was conducted with low-income students.

APPENDIX J

Home-School Links Programs and Effect Sizes for Girls

Study	Indicator(s)	*N*	*d* (effect size)	95% Confidence Interval Lower Limit	95% Confidence Interval Upper Limit
Laptop Programs					
Stevenson (1998)	MAT7 NCErr* (8th)	588	+0.79	+0.58	+1.00
Discrete Software Programs					
Gwaltney (2000)	MAT7 Reading (4th)	141	+0.18	-0.15	+0.52
Gwaltney (2000)	MAT7 Reading (5th)	106	-0.14	-0.52	+0.25
Gwaltney (2000)	MAT7 Math (4th)	143	+0.28	-0.05	+0.61
Gwaltney (2000)	MAT7 Math (5th)	106	-0.31	-0.70	+0.08

*NCErr is a composite score that includes reading and mathematics achievement levels. Stevenson (1998) did not report data on subscales of the MAT7.

APPENDIX K

Home-School Links Programs and Effect Sizes for Boys

Study	Indicator(s)	*N*	*d* (effect size)	95% Confidence Interval Lower Limit	Upper Limit
Laptop Programs					
Stevenson (1998)	MAT7 NCErr* (8th)	574	+0.67	+0.42	+0.92
Discrete Software Programs					
Gwaltney (2000)	MAT7 Reading (4th)	129	+0.77	+0.41	+1.13
Gwaltney (2000)	MAT7 Reading (5th)	90	-0.29	-0.71	+0.12
Gwaltney (2000)	MAT7 Math (4th)	129	+0.02	-0.32	+0.37
Gwaltney (2000)	MAT7 Math (5th)	107	-0.23	-0.61	+0.16

*NCErr is a composite score that includes reading and mathematics achievement levels. Stevenson (1998) did not report data on subscales of the MAT7.

APPENDIX L

Home-School Links Programs and Parent-School Communication Effect Sizes

Study	Indicator(s)	*N*	*d* (effect size)	95% Confidence Interval	
				Lower Limit	Upper Limit
Laptop Programs					
Myers (1996)	Parent attitudes toward school and toward family involvement (3rd-5th)	70	-0.72	-1.07	-0.38
Myers (1996)	Strength of family-initiated learning activities and parent-school communication (3rd-5th)	68	+0.34	+0.02	+0.33
Myers (1996)	Strength of school-initiated learning activities and parent-school communication (3rd-5th)	68	+0.17	-0.30	+0.65
Voicemail Programs					
Cameron & Lee (1997)	Parents' familiarity with teacher (K, 4th)	44	+0.23	-0.36	+0.83
Cameron & Lee (1997)	Change in home-school communications (K, 4th)	44	+0.72	+0.11	+1.33
Cameron & Lee (1997)	Change in parents' knowledge of school activities (K, 4th)	44	+0.26	-0.34	+0.85
Cameron & Lee (1997)	Change in parents' knowledge of children's school behavior (K, 4th)	44	+0.47	-0.13	+1.07

APPENDIX M

Home-School Links Programs and Effect Sizes for Low-Achieving Students

Study	Indicator(s)	*N*	*d* (*effect size*)	95% Confidence Interval Lower Limit	95% Confidence Interval Upper Limit
Discrete Software Programs					
Gwaltney (1998)	MAT7 Reading (3rd)	141	-0.72	-1.07	-0.38
Gwaltney (1998)	MAT7 Reading (4th)	154	+0.34	+0.02	+0.66
Gwaltney (1998)	MAT7 Reading (5th)	81	+0.14	-0.29	+0.58
Gwaltney (1999)	MAT7 Reading (3rd)	141	+0.14	-0.29	+0.58
Gwaltney (1999)	MAT7 Reading (4th)	109	+0.09	-0.29	+0.47
Gwaltney (1999)	MAT7 Reading (5th)	105	+0.34	-0.05	+0.72
Gwaltney (1998)	MAT7 Math (3rd)	145	+0.24	-0.09	+0.57
Gwaltney (1998)	MAT7 Math (4th)	148	-0.16	-0.49	+0.16
Gwaltney (1998)	MAT7 Math (5th)	86	+0.13	-0.29	+0.56
Gwaltney (1999)	MAT7 Math (3rd)	116	-0.02	-0.39	+0.34
Gwaltney (1999)	MAT7 Math (4th)	106	+0.41	-0.02	+0.80
Gwaltney (1999)	MAT7 Math (5th)	95	+0.09	-0.31	+0.49