A Research Review of Technology in Early Childhood Education: Implications for Best Practice

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ABSTRACT

The purpose of this review of research is to describe the integration of technology in the early childhood curriculum. The review presents issues surrounding the use of technology in early childhood education; synthesizes research findings on the impact of technology use on young children’s educational achievement; provides professionals in the field with instructional strategies for integrating technology in a variety of content areas within the early childhood curriculum; and shares recommendations for the developmentally appropriate and effective use of technology for young children. This review supports the professional growth of early childhood professionals by facilitating their understanding of research-based practices that utilize technology. This research-oriented knowledge base is essential as early childhood educators consider their perceptions and beliefs about the use of technology with young children and confront any biases that may exist. The research findings may be used as a yardstick by which educators measure their current level of expertise, self-assess their learning needs, and take steps to implement technology as a tool for promoting the educational growth of each of their young learners. This aspect of technology integration is crucial, given that the types of background experiences and range of exposure to technology that young children bring to the learning situation can be vast. Additionally, this research review may be used to guide administrators in providing teachers of young children with the tools they need to promote best practices in technology integration. Lastly, the synthesis of research informs teacher educators as they prepare their preservice teachers to enter the field of early childhood education ready to meet the unique needs of young children. Steps must be taken to ensure that technology is available for young children and that its use is both developmentally appropriate and effective. Further, professional development should involve a long-term commitment to provide on-going support based upon individual teachers’ needs.
INTRODUCTION

The integration of technology in the early childhood curriculum is a complex process that involves several elements for implementation to be successful. By infusing technology in the early childhood curriculum, educators are allowing their students to be involved in what Williams [as cited in Siu & Lam, 2005] describes as a fast-changing world that is driven by technology, where technology affects the daily lives of every person, directly or indirectly. Computers are a part of many children’s preschool experiences [Fischer & Gillespie, 2003] and children should be helped to become confident users of Information and Communication Technologies (ICT) [Stephen & Plowman, 2003].

The purpose of this research review is to describe research studies that relate to technology integration in early childhood programs and identify key aspects of its effective use with young children. Judge, Puckett, and Cabuk [2004] explain that there is not a single operational definition of technology. For the purpose of this chapter, technology refers to aspects of computer use, including software and the use of the Internet. The rationale behind this chapter is the understanding that early childhood programs and curricula vary among different settings; therefore, the use of technology also varies, for a variety of reasons. Consequently, “each early education program has unique circumstances leading to the development of its own philosophy about the role technology should play in its setting, and the resulting strategy” [Blagojevic, 2003, p.32]. Issues that relate to funding, developmentally appropriate and effective practices, and professional development influence technology integration.
Related to the variability that exists among programs, Siu and Lam [2005] argue that early childhood technology curriculum development should go beyond technical aspects and consider social and cultural factors. These factors are: (1) background of the students and their parents; (2) society’s perceptions of technology; (3) society’s expectations of children who learn about technology; and (4) the approach and method of teaching and learning technology. With these social and cultural considerations in mind, this review of research seeks to answer the following questions:

- What are the issues surrounding the use of technology in early childhood education?
- How does the use of technology promote the achievement of student learning outcomes in the early grades?
- In what developmentally appropriate and effective ways is technology used to enhance the learning experiences of young children?
- What supports do early childhood professionals need to be able to effectively utilize technology in early childhood settings?

This chapter begins with a description of issues that surround the use of technology in early childhood education. The chapter then reports on the impact of technology on the achievement of young children. Next, it provides a discussion of instructional strategies and research-supported practices before it turns to a description of the ways in which technology is integrated in the early childhood curriculum. The chapter then details developmentally appropriate and effective practices for technology use with young children. Finally, the chapter concludes with a summary of research surrounding
professional development in the field of early childhood education and the ways in which early childhood educators may impact family literacy through the use of technology.

Issues Surrounding the Use of Technology in Early Childhood Education

While the potential benefits and hazards associated with computer use by young children continues to be debated, a consensus is emerging in the United Kingdom that supports the use of ICT as a valuable tool that educators may use for motivating and engaging children in areas of the curriculum they might otherwise reject [Stephen & Plowman, 2003]. Given the benefits of using ICT, Stephen and Plowman also present a concern surrounding the use of ICT that relates to inequalities and the lack of equitable access families have to a home computer. This section presents a look at issues that relate to funding and equity, followed by a discussion that relates to the issue of developmental concerns.

Funding and Equity Issues

Children need a regular approach to using technology while they are at school [Siu & Lam, 2005]; however, having access to technology may be an issue for some children. This issue relates to digital equity, which Judge, Puckett, and Cabuk [as cited in National Institute for Community Innovations, 2003] explain as:

a social justice goal of ensuring that all students have access to information and communications technologies for learning regardless of socioeconomic status, physical disability, language, race, gender, or any other characteristics that have been linked with unequal treatment. Equitable access to technology resources (computers, software, connectivity) is one aspect of digital equity concerns. Other dimensions include effective use of technology for teaching and learning, access
to content that is of high quality and culturally relevant, and opportunities to create new content. [p. 383]

In a later publication, Judge, Puckett, and Bell [2006] echo that definition and elaborate, “If one assumes that academic achievement is facilitated by access to computers at home and at school, the gap in access to computer technology is cause for concern” [p. 52]. Judge, Puckett, and Cabuk [2004] found that American public schools are making progress towards digital equity for all groups of students. An additional finding was that the student-to-computer ratio for young children needs to decrease. Judge and colleagues examined the access to computers in school and at home for 9,840 kindergarten and first grade children, and the varying conditions that affect how they experience computers. They report that lower and higher poverty schools are about equally likely to have computers available for children when they start their formal schooling but the digital gap starts to widen as children move into first grade. Young children’s use of computers in their classrooms differed by school poverty status and it was also found that children attending higher poverty schools had significantly fewer computers and software programs available. Another perspective is offered by Kennewell and Morgan [2006] whose research found that access to technology at home seems to have little effect on children’s subsequent learning.

note that technology in the home is becoming increasingly available. Judge and colleagues [2006] report that in third grade, high-poverty schools had more computers for instruction and a smaller ratio of children to computers than did low-poverty schools, but over the first four years of school, children attending low-poverty schools had more access to computers at home.

Equal resources, according to Celano and Neuman [2006], do not always result in equal educational experience. After technological improvements were made to urban libraries, the authors compared the types of computer activities used by children from low-income and middle-income neighborhoods, along with the amount of time spent on their chosen activities. Celano and Neuman report that while low-income neighborhood children spent more time in the computer section of the library, this group of children “spent more time on gaming activities that contained little print; children from middle-income neighborhoods spent more time on content applications with more print” [p. 195]. The study resulted in what the authors refer to as a wider knowledge gap between low-income and middle-income children, despite providing equal access to resources. Celano and Neuman believe that “the knowledge gap, representing differentials in information acquired and retained and related to income and social disparities, may be far more important in affecting people’s incomes, their social mobility, and ultimately their quality of life” [p. 199]. This knowledge gap mirrors the findings of Judge, Puckett, and Cabuk [2004], in which the differing uses of technology among high- and low-poverty schools indicate a cause for concern; specifically that “progress in computer availability does not always insure equitable use” [p. 393]. Similarly, Espinosa and colleagues [2006]
emphasize that just having access to technology at home is unlikely to be sufficient for young children to benefit from technology.

Developmental Concerns

Fischer and Gillespie [2003] contend that early childhood educators need to understand how exposure to computers and constructive computer programs affects the development of children. The following statistics published by The Henry J. Kaiser Family Foundation [2003] illustrate how computers are being used by young children:

- 48% of children six and under have used a computer
- 68% of children under two will use screen media, on any given day, for an average of just over two hours
- 27% of 4-6 year-olds use a computer, with about an hour on the keyboard
- 39% of 4-6 year-olds use a computer several times a week or more
- 37% of 4-6 year-olds can turn the computer on by themselves
- 40% of 4-6 year-olds can load a CD-ROM

Computers are increasingly a common part of preschoolers’ lives [Murphy, DePasquale, & McNamara, 2003; Vernadakis, Avgerinos, Tsitskari, & Zachopoulou, 2005], and while a study conducted by Judge, Puckett, and Cabuk [2004] found that young children’s use of the Internet is minimal, research also shows that its use in early education continues to grow [Hillman & Moore, 2004]. Miller [2005] cautions that we need to slow down the rush to put toddlers and preschoolers in front of computer screens.

Wartella, Vandewater, and Rideout [2005] describe the computer game market as a multimillion dollar industry and provide the example of special keyboard toppers designed for children as young as nine months old. Miller [2005] attributes the pressure
that parents exert as one reason that educators rush to use technology with young children. Another reason, according to Miller, is the push for academic rigor in the early childhood curriculum that is evidenced by standards. The International Society for Technology in Education advocates using computer technology with young children to build their technological skill and comfort level [Pearman & Lefever-Davis, 2006].

A concern is presented by Miller [2005], who claims educators report that children who are adept at using computers show lack of imagination. Miller advises that we need to “open a wide-ranging debate about the proper role of advanced technologies in young children’s lives” [p. 58]. This debate also includes the use of the Web by young children [Hillman & Moore, 2004]. Miller states:

The primary work of the young child, according to Tufts University psychologist David Elkind, is to master the skills of regulating emotions; solving problems; developing flexibility, imagination, and persistence; paying attention; coordinating body movement; and negotiating social situations. There is no evidence that young children learn these skills better through high technology, and there is abundant evidence that they learn them best through direct interaction with other people. [p. 56]

Vernadakis et al. [2005] conducted a study to determine if computer assisted instruction (CAI) was a useful tool to enhance preschoolers’ cognitive, emotional, linguistic, and literacy skills. The authors report that CAI programs may never replace the book and the blackboard but were more accessible by young children, who learn better with pictures and sounds; further, computers make a significant contribution in the classroom as a learning tool. Another form of technology that has been researched is the
use of personal digital assistants (PDAs). Chang, Mullen, and Stuve [2005] share insight on the use of PDAs with kindergarten children. They concluded the PDA may be more suitable for young children due to its simpler operation when compared to a desktop computer. Further, the PDAs captured children’s interests and stimulated their ability to pursue their own line of inquiry. In regard to developmentally appropriate practices, Chang et al. indicate that appropriate use of PDAs depends on implementation; children should be autonomous and in control of the learning activity.

Impact of Technology on Young Children’s Educational Achievement

This section will describe studies that determine how the use of technology in the early childhood curriculum affects the achievement of young children. Wenglinsky [2005/2006] underscores the importance of asking whether technology raises student achievement. His current article, which focuses on 12th grade history, reiterates findings from his 1998 study on younger students: (1) the quality of computer work is more important than the quantity; and (2) computers are typically not being used in the most effective ways, such as promoting critical thinking skills. In the area of literacy, Bauserman, Cassady, Smith, and Stroud [2005] found that the use of an integrated learning system (ILS) positively impacts kindergarten emergent reading skills.

Research conducted by Kennewell and Morgan [2006] found a positive relationship between learners’ self-belief with ICT and subsequent attainment through play activity. Wood, Littleton, and Chera [2005] conducted a study to investigate young children’s collaborative working styles while using computers with a peer. After pairing children according to equal and unequal reading attainment, the researchers found that
reading attainment and/or gender may be more significant factors in determining the nature of children’s collaborative activity than pair type.

Another positive finding for the use of technology is associated with access to technology in the home. Espinosa and colleagues’ examination of data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 [U.S. Department of Education] shows that having access to technology contributes significantly to the reading and math achievement of young children.

A study was conducted by Weiss, Kramarski, and Talis [2006] to investigate the effects of learning mathematics with multimedia embedded in different styles of learning, cooperative learning (CL) and individual learning (IL), on kindergarten students’ mathematical achievements and to examine students’ preference for style of learning with computers in kindergarten. They found that the CL and IL students significantly outperformed the control group in mathematical achievement. The IL students further improved their mathematical skills at a higher level, while the CL students further increased their positive attitude about cooperative learning.

Laffey, Espinosa, Moore, and Lodree [2003] conducted an exploratory study on interactive computer technology (ICT) in supporting learning and behavior of young children who are at risk because of behavior problems. The study compared the performance of young, urban, African-American children from low-socioeconomic-status homes who were given specially selected ICT experiences with a comparison group who did not have the ICT treatment. The study also compared the performance of children identified as with or without behavioral problems but not identified as special education. The authors concluded that ICT has potential to engage young children in learning
activities; further, the children who received ICT experience made gains in mathematics knowledge greater than the children in the comparison group.

A study conducted by Clements and Sarama [2007] evaluated the efficacy of a preschool mathematics program that involved research-based technology-enhanced mathematics materials for grades PreK-2. The treatment group score increased significantly more than the comparison score, which shows that focused early mathematical interventions, such as this one that used technology, develop a foundation of mathematics knowledge, especially for children at risk for later school failure.

Instructional Strategies and Research-Supported Best Practices

This section begins with a description of technology-based research that relates to the broad early childhood curriculum. It then turns to what Robinson [2003] describes as the important role that technology plays in promoting literacy. Lastly, the use of technology to meet the diverse needs of individual students will be shared.

Instructional Strategies throughout the Curriculum

Technology should be used as a tool that is selected because “it is the best tool for the job” and to “deepen children’s engagement in meaningful and intellectually authentic curriculum” [Murphy, DePasquale, & McNamara, 2003, p. 13]. Fischer and Gillespie [2003] offer the following suggestions for computer use in early childhood classrooms:

- Build learning centers around technology and offer children a variety of choices so that children do not spend all of their time in any one center.
- Use developmentally appropriate, open-ended project software rather than drill-and-practice software.
- Encourage social interaction by providing opportunities for children to cooperate, communicate, and assist one another.
- Limit total screen time to no more than two hours per day, with frequent breaks; including television viewing time.
- Position the computer screen so that children’s eyes are 18-22 inches away.

Instructional Strategies for Promoting Literacy

Technology can serve as a scaffold for literacy development and the use of customized storybooks are relevant because they contain personally, culturally, and linguistically meaningful content for young children [Robinson, 2003]. DVD technology was used for shared reading experiences provided by Skouge, Rao, and Boisvert [2007]. Technology provides instructional support through an approach called the “vocabulary flood instructional cycle” [Labbo, Love, & Ryan, 2007, p. 586]. Students who participated in this strategy showed gains in vocabulary knowledge. This approach used computer-related activities to assist in promoting vocabulary learning with children from low socioeconomic backgrounds.

In addition to the vocabulary flood instructional cycle, Labbo et al. also used the Digital Language Experience Approach (D-LEA) [as cited in Labbo, Eakle, & Montero, 2002] and described both the vocabulary flood and D-LEA as effective means for focusing “students’ attention on visual representations of vocabulary terms” [p. 587]. “The D-LEA consists of four steps: (1) setting up the experience, (2) photographing the experience, (3) composing a multimedia photo essay or story, and (4) engaging in follow-up activities” [Labbo, Love, & Ryan, 2007, p. 583]. A similar approach was used by Skouge et al. [2007], who combined the language experience approach with video. This
approach is the opposite of drill-and-practice activities as it promotes creativity, is open-ended, and provides a medium for a supportive environment, which are key components of technology use for preschool children. Digital imagery allows children to remember and reflect on experiences; it also leads to discussion and extends to writing, drawing, or other forms of expression [Murphy, DePasquale, & McNamara, 2003].

The first author in this chapter, Laverick, used a research-based approach [Labbo et al., 2007; Murphy et al., 2003; & Vernadakis et al., 2005] to inform her instruction by using an interactive digital whiteboard to create a class collaborative story. Similar to the approach described in Labbo et al., Laverick typed her students’ collective story on the computer as the children dictated the words. The enlarged text provided a means for practicing reading the story fluently and teaching literacy concepts. The final copy was printed and sent home for families to enjoy and practice reading with their children. In addition to facilitating the cognitive, linguistic, and literacy skills described by Vernadakis et al., Laverick’s activity also served the emotional needs of the children through the group support and composition process. This process fostered collaboration and teamwork as the group created a whole-class story.

Technology may be used to promote literacy through the use of on-line texts provided by the Internet [Hillman & Moore, 2004] and through the use of interactive storybooks. CD-ROM storybooks can support the development of the five essential elements of reading instruction identified by The National Reading Panel: phonemic awareness, phonics, fluency, vocabulary, and comprehension [Pearman & Lefever-Davis, 2006]. According to the authors, the features that enable these texts to support the
development of readers are: audio pronunciation of text, embedded vocabulary
definitions, and animated graphics.

Grant [2004] also found that using electronic books in conjunction with other
pedagogical methods improves reading comprehension. Robinson [2003] suggests that
technology enhances storybook reading experiences. “When used along with traditional
storybooks, multimedia versions of books provide children between two and three years
of age with an interactive literacy experience shaped by a child’s social and cultural
environment, because the stories can be personalized” [p. 44].

While the use of interactive storybooks in the primary classroom has the potential
to facilitate pupils’ reading, in small groups or individually, critics have also expressed
concern at the exposure of pupils to interactive storybooks. In particular, concern has
been expressed that the interactive animations and sound effects in such storybooks may
adversely affect pupils’ responses to the written text. Trushell and Maitland [2005] found
that access to cued animations and sound effects had adverse effects on pupils’ story
recall.

Features of storybook software to consider are: (1) stories related to real-life
experiences; (2) stories with repetition/predictable text; and (3) stories with
rhymes/rhythm [Robinson, 2003]. To assist early childhood educators in determining
appropriate storybook software for children ages 18 to 36 months, Robinson advises that
educators should consider: (1) the level of interactivity and (2) whether the book features
are appropriate for younger children.
Meeting the Diverse Needs of Learners

Assistive technology (AT) is the focus of a strand of literature that relates to meeting the needs of diverse learners. AT “refers to both high- and low-tech tools that allow people of all ages to be more independent” [Mulligan, 2003, p. 50]. AT consists of “two interrelated components: (a) adaptations and devices and (b) services to identify adaptations and devices and teach children and families to use them successfully” [Campbell, Milbourne, Dugan, & Wilcox, 2006, p. 3]. Judge [2006] notes that assistive technology is guaranteed by law to be included, when appropriate, on individualized education plans (IEP) for young children with disabilities; yet, the full potential of technology remains unfulfilled due to insufficient knowledge of options available, limited professional development, and a dearth of evidence on its effectiveness for particular daily routines and activities. Mulligan stresses that “even the most sophisticated device won’t help unless it matches the child’s abilities and the demands of the environment” [p. 51]. A good match between a child and AT allows the child to be more independent and expressive [Mulligan].

A review of research conducted by Campbell et al. [2006] for articles published from 1980 through 2004 discussed the use of assistive technology devices by young children with physical or multiple disabilities. Campbell et al. report that practice has made children more competent in using the devices. Judge [2006] described a proactive strategy for meeting the needs of young children with disabilities through an assistive technology toolkit approach that supports the learning, language, and motor development of young children. In this study, surveys were completed by early childhood special education professionals to assess which assistive technology tools were most useful for
working with young children with disabilities. Results indicated that communication and low-technology devices were considered most useful.

Hardware and software technological devices are required by law under Title 111.4 of ADA to be available for special education students. The use of electronic books or digital technology enhanced the quality of education of students in special education [Grant, 2004]. Practical applications of multimedia technologies that support early literacy were described and evaluated by Skouge et al. [2007] who posit that “technology under qualified conditions can serve to build literacy-rich contexts for children, in which stories that otherwise go untold and unread, can be made accessible to children and families” [p.11]. Skouge and colleagues’ approach included the use of several variations of recorded books and stories utilizing mainstream audio and video recording appropriate for libraries and schools. Their work demonstrates how to support the needs of children with disabilities and children who are acquiring a new language.

A group study conducted by Lau, Higgins, Gelfer, Hong, and Miller [2005] investigated the impact of teacher facilitation on the social interactions of young children during computer activities. Children in the study exhibited few negative social interactions regardless of their age, disability status, or intervention group assignment. The children with and without disabilities in the teacher-facilitated computer group had more positive social interactions and demonstrated more effective social behaviors than the children in the computer-only group. The implications of this study involve the benefits that children with and without disabilities attain from social skill instruction; therefore, practitioners may use a structured computer activity as an alternative to free play for promoting social interactions among children.
Another study that relates to meeting the needs of diverse learners and promoting social interactions was conducted by Hertzog & Klein [2005], who discussed the different ways in which kindergarten and first grade teachers incorporated technology into their classrooms of gifted students: through computers, digital cameras, email, and scanners. The teachers introduced software termed as being kid-friendly and which promotes critical and creative thinking. The children were engaged in individual and group projects and shared their projects with their classmates. Other benefits shared in this article are: reflection on learning is enhanced; children enjoy becoming technology-literate; the curriculum is differentiated; technology supports the transition from concrete experiences to abstract concepts; and growth in the areas of social, emotional, and cognitive domains.

When computers are used appropriately, they can make a “unique and substantial contribution to the education of young children” [Clements & Sarama, 2003, p. 40]. The instructional strategies and research-supported practices, described in this section, for using technology effectively in the early childhood curriculum may be accomplished through the use of a “technology toolkit” [Murphy et al., 2003, pp. 14-15]. This toolkit is comprised of the following applications:

- Digital imagery
- Word processing and writing tools
- Computer art programs
- Presentation software
- Research tools
- Concept mapping software
The next section elaborates on how technology is integrated in the early childhood curriculum.

**Integrating Technology in the Early Childhood Curriculum**

In order for technology to have an impact on learning in the early childhood classroom, it must be effectively integrated into the curriculum. The “Eight Cs” concept [Siu & Lam, 2003] provides early childhood professionals with a helpful resource for accomplishing this goal [as cited in Siu, 2002]:

1. **Competent**—“The technology curriculum should prepare young children to be competent in handling simple tools and techniques to present and demonstrate their understanding of technological knowledge and to illustrate their ideas” [p. 145].

2. **Comprehensive**—Children should be allowed to explore many aspects of technology.

3. **Critical**—“Technology should also aim at facilitating and encouraging higher order thinking skills as young children question, explore, analyze, give answers/solutions, and evaluate” [p. 146].

4. **Creative**—“A technology curriculum should have different kinds and levels of activities to encourage children to generate and present creative ideas” [p. 147].

5. **Curious**—Curiosity is a crucial factor in helping children become successful in critical and creative thinking.

6. **Collaborative**—Teachers should establish an environment where technology learning activities provide children with opportunities to interact, communicate, and collaborate with others.
7. Continuous-The technology curriculum should be continuously reviewed and updated.

8. Compulsory-It should be compulsory for both girls and boys to take technology courses; barriers that hinder children with special needs should be eliminated, or at least, lessened.

School districts are finding that simply supplying teachers with technology does not ensure that the technology is being utilized in meaningful ways. Project TIME (Technology Integrated into Meaningful Learning Experiences), a group of educators from the Battle Creek Area Staff Development Consortium, developed a framework for meaningful learning using technology (MLT) through a grant from the U.S. Department of Education [Battle Creek Area Educators’ Task Force, 2002]. The MLT framework is based on the research of Jonassen, Peck & Wilson [1999] and includes six methods for achieving effective technology use in the classroom:

1. Use clear goals as you design learning through technology.

2. Match the learning goals to learning tasks.

3. Design real/authentic tasks.

4. Use active inquiry to have students develop questions that lead to higher-level thinking.

5. Help learners to develop complex and accurate mental models of the content that they are studying.

6. Have students work in groups [Ashburn, 2006].
When used interdependently, as the following example demonstrates, these methods can increase student motivation, enhance learning, improve social skills, and build confidence [Mouza, 2005].

During a summer technology conference in 2000, six teachers and one technology coordinator from a New York City elementary school designed a technology-enhanced, interdisciplinary curriculum called the 100 Days of School project for students in grades K-2. The project included four units that focused on the number 100 and met standards in language arts, social studies, math, science, and technology [Mouza, 2005].

In the first unit, students surveyed 100 school employees about their transportation to school (kindergarten), their favorite place to eat (first grade), the number of years they had been teaching and what they enjoyed most about the school (second grade). To collect the data, students used tape recorders and worked in groups. Teachers initially taught the students how to tally and analyze their responses using objects and manipulatives. Then, the students were introduced to a software program that allowed them to create different types of graphs and see the relationship between diverse representations of their data [Mouza, 2005].

The second unit involved creating recipes with 100 ingredients. Teachers sparked interest in this topic by reading and discussing books that included recipes. Students then prepared recipes related to the books the teachers read to them. Kindergarten and first-grade students used a software program to illustrate the process of creating a recipe. Second-grade students also used a word processing program to type their recipes. Each class compiled its recipes into a cookbook. Some classes combined what they learned from the recipe unit with what they learned from the graphing unit to graph the number of
ingredients they included in their recipes. Counting the number of ingredients they added to their recipes developed students’ number sense, following recipe directions taught them about sequencing, and graphing the number of ingredients in their recipes reinforced their graphing skills [Mouza, 2005].

In the third unit, students created poems with 100 words. The words had to be paired together (such as mitten and hand) in kindergarten. First graders had to rhyme their words, and second graders used words that were opposites. After they wrote their poems, students worked in pairs to create illustrations using a computer software program. Some teachers created anthologies of their students’ poetry. Through the 100-word poetry unit, students developed skills in language arts, writing, technology and the arts [Mouza, 2005].

The final unit of the 100 Days of School project was entitled A Quest of Knowledge in the World of Toys. In this unit, teachers developed a WebQuest that enabled students to learn about daily living in the United States 100 years ago through the study of toys. At the beginning of this unit, teachers raised student interest by looking at historical books and having students create personal timelines. The WebQuest focused on pictures and descriptions of toys from the past and present. After completing the WebQuest, students listed similarities and differences between past and present-day toys in order to predict the kinds of toys that would be manufactured in the future. This activity required higher-level thinking and taught students about eras in United States history [Mouza, 2005].

All four units in the 100 Days of School project achieved meaningful learning through the use of technology and the methods used by the teachers from the MLT
framework [Ashburn, 2006]. First, they set clear goals by addressing specific New York State language arts, mathematics, science, technology, and social studies standards. Next, they matched their goals to the task. For example, the teachers wanted their students to learn about sequencing, so they designed a recipe unit which required students to write and follow directions in a specific order. Following the directions in a recipe is a real/authentic task, as is interviewing employees and writing and illustrating poetry.

Active inquiry was used quite often to elicit higher-level thinking, especially in Unit 4 where students used the Internet to answer their questions about toys and predict the toys of the future. The use of graphs, illustrations, and timelines helped the students develop complex and accurate mental pictures of research data, literature, and history. Finally, two of the four units required students to work collaboratively.

As a result of implementing the MLT framework, the New York City teachers and technology coordinator saw student achievement rise in the areas of motivation, skill, confidence, and social development. Teachers noticed that students were eager to use technology in the classroom. They also observed that students who were typically less motivated became highly engaged when technology was introduced. Furthermore, the integration of technology improved students’ writing skills because they could easily identify and fix mistakes by using a word processor. The word processing program also made it possible for students to focus on the content and mechanics of their writing rather than the motor skills required to write by hand [Mouza, 2005].

As much as word processing improved the literacy skills of the students in this study, spreadsheets improved their mathematics skills by helping them analyze data, pose and solve problems, and recognize patterns. All of these skills are normally taught at a
level well above second grade. The use of technology enabled students in grades K-2 to produce work that teachers normally see from students in upper elementary grade levels. Teachers reported a great sense of pride and confidence in their students. Students were also very proud to share their work with peers when they worked with a partner or group. As they explained their work to group members, they increased their level of confidence and became better verbal communicators [Mouza, 2005].

There is much debate about the effect of technology, specifically computers, on the social development of young children in the classroom [Attewell, Suazo-Garcia & Battle, 2003; Cordes & Miller, 2000; Svensson, 2000; Wright, 2001]. Some parents and educators feel that computers isolate children. Teachers in the New York City elementary school study disagreed. One teacher observed, “Working on the computer encouraged children to socialize and interact with one another. Even students who were shy started talking and feeling more comfortable when working on the computer” [Mouza, 2005, p. 525]. In fact, there are numerous studies that have found the use of technology in the classroom to benefit the social development of young children [Fischer & Gillespie, 2003; Hertzog & Klein, 2005; Kumtepe, 2006; Weiss, Kramarski & Talis, 2006]. For technology to have a positive effect on social development, however, teachers must use it in a developmentally appropriate manner [Fischer & Gillespie, 2003].

Developmentally Appropriate and Effective Use of Technology with Young Children

According to the National Association for the Education of Young Children (NAEYC), a child’s development includes cognitive, social, physical, and emotional growth [1997]. These areas of growth often overlap and influence one another. For example, children who are learning to speak develop their cognitive skills by attempting
to understand and learn language. The use of this language to understand and be understood by others promotes social growth. Children must also control their mouth muscles and breathing in order to correctly pronounce words; as a result, they grow physically. Finally, emotional growth occurs when children build relationships through oral communication [Cooper, 2005].

Cognitive Development

Children develop and grow cognitively by moving through sequential stages. Each stage builds upon the knowledge and skills learned in previous stages [Piaget, 1977]. Early childhood encompasses Piaget’s sensorimotor, preoperational, and concrete operational stages. Most children in preschool have moved from Piaget’s sensorimotor stage (learning through tasting, touching, and crawling) to his preoperational stage. During the preoperational stage, children begin to use language and symbols. They do not understand concrete logic, cannot mentally manipulate information, and see things only from their own point of view. At about second grade, children enter the concrete operational stage. In this stage, they begin thinking logically about concrete events but have difficulty understanding abstract or hypothetical concepts. Many would argue that young children in the concrete operational, and especially preoperational stages, are not ready to use computers for learning [Cordes & Miller, 2000; Elkind, 1987; Healy, 1998; Miller, 2005; Yelland, 1999]. These opponents of technology integration in the early childhood curriculum claim that “computers are two-dimensional, calling for formal operations and thus outside (young children’s) stage of development” [Mitchell & Dunbar, 2006, p. 244]. However, several studies have shown that computers can be effective tools in the early childhood classroom [Clements & Sarama, 2003], provided
teachers choose developmentally appropriate software [Fischer & Gillespie, 2003] which is engaging and encourages interaction among children while it is being used [Mitchell & Dunbar, 2006].

In a study conducted by Mitchell & Dunbar [2006], preschool children completed several tasks on the computer that they would normally perform in a computer-free classroom. These tasks included identifying letters, words, and sounds; sequencing; prediction; color, shape and pattern recognition; and problem solving. One of the first things the researchers noticed is that the preschoolers were able to concentrate and persist longer when computers were used to complete these tasks. They also found that when the children were able to joint problem-solve, they thought aloud, questioned each other, justified their thoughts and decisions, made predictions, and suggested solutions to problems. “The joint construction of knowledge was well demonstrated in those settings where children were encouraged to engage in collaborative problem-solving and where adult intervention facilitated discussion and helped children to make their thought processes explicit” [Mitchell & Dunbar, 2006, p. 253]. Mitchell and Dunbar concluded that cognitive development occurred as a result of engaging software, social interaction, and teacher guidance.

Social Development

One of the most popular arguments against the integration of technology in the classroom is that computer use promotes social isolation [Miller, 2005]. The results of the Mitchell/Dunbar study, as well as the results of several other studies [Anderson, Hilton, Wouden-Miller, 2003; Clements & Sarama, 2003; Kumtepe, 2006] show otherwise. Computers can serve as “catalysts of social interaction” [Clements & Sarama, 2002, p.
340]. While working on computers, children help each other, peer teach, engage in discussion, and build on other students’ ideas [Clements & Sarama]. Plowman and Stephen [2005] found that children socialize with one another at the computer in three ways. First, they negotiate turns when there are not enough computers to go around. Second, they help each other decide what to click or type. Third, they celebrate together when they complete a task successfully or share their enjoyment of something fun or exciting on the screen.

Not only can the right software excite a student and make learning fun, but different kinds of programs can teach children different social skills. For example, drill and practice software teaches children how to take turns, while open-ended software promotes collaboration. Of course, for turn-taking and collaboration to occur, equipment must be set up to facilitate socialization. Computer stations should be centrally located to provide easy access for students and visibility to teachers, and each computer should have at least two chairs in front of it, with a chair for the teacher placed nearby [Clements & Sarama, 2002].

Physical Development

While the placement of hardware in the classroom is important to the social development of children, the kind of hardware that is used can be crucial to their physical development. Scaife and Bond conducted a study in 1991 to determine children’s developmental differences in using various input devices. They observed 228 children between the ages of five and ten using a touch screen, mouse, joy-stick, and key-push. They found that the youngest children had trouble using the mouse and joy-stick. Liu [1996] agrees and recommends keyboards and touch screens for early childhood
classrooms. A normal-sized keyboard is easier for a child to manipulate than a pen or pencil and is less-frustrating, since the child can concentrate on the task at hand rather than spending a lot of time trying to form letters properly. Access to a large keyboard makes typing even easier. In addition, children who have difficulty manipulating a mouse can interact with software more effectively by using a touch screen. Mitchell and Dunbar [2006] found that using a keyboard and/or touch screen improved students’ hand-eye coordination and fine motor skills.

Just as large keys and touch screens are more physically appropriate for young children, so too are larger fonts, icons, colorful screens, and screen consistency. Large fonts and less wording on a page make it easier for nonreaders, beginning readers, and emergent readers to follow and scan text. Furthermore, words appearing in both text and icon format teach children to read as they match pictures with words. Bright colors and simple, recognizable shapes engage but do not over-stimulate children. Finally, good software programs maintain consistency on every screen, keeping text, icons, and buttons in the same places for easy navigation [Liu, 1996].

Emotional Development

The last facet of a child’s development is his/her emotional growth. Like Piaget, Erikson [1963] believed that humans develop through a series of stages. His psychosocial stage theory is based upon the idea that humans must develop ego identity, or an understanding of themselves through social interaction. According to Erikson, ego identity is constantly changing due to new experiences and interactions with others. Most preschool children are in Erikson’s initiative vs. guilt stage. In this stage, children begin to take control of their world by directing play and socializing with others. Children who
are not given the opportunity to play or socialize have feelings of guilt, doubt themselves, and lack initiative. Children who successfully complete this stage (usually by kindergarten or first grade) feel capable of leading others and move on to Erikson’s *industry vs. inferiority* stage. In this stage, children begin to develop a sense of pride in their accomplishments and abilities. In order to feel that they can be successful, children must be encouraged by parents, teachers, and peers. Both the *initiative vs. guilt* and *industry vs. inferiority* stages require support if a child is to mature emotionally.

Carefully chosen technology can provide the kind of emotional support that growing children need to mature. Software that gives children the opportunity to avoid or fix mistakes, go back and review concepts again, and receive positive feedback builds confidence and raises self-esteem [Liu, 1996]. In the Mitchell and Dunbar [2006] study, children experienced many positive emotions as a result of using computers in a social setting. They felt enjoyment, satisfaction, and a shared sense of achievement. “Not only does it (the computer) allow the child a ‘safe’ environment in which she or he can be a risk-taker and ‘have a go’ without fear of reprimand for making a mistake or being wrong, but also it can provide a sense of achievement, thereby enhancing self-confidence and self-esteem” [pp. 251-252]. Fischer and Gillespie [2003] explain developmentally appropriate practice as being “determined by what is appropriate for a particular age level and by what is appropriate for an individual child” [p.85]. As early childhood professionals evaluate appropriate and effective uses of technology, the importance of meeting individual needs must be underscored.
Professional Development for Professionals in Early Childhood Education

Despite the benefits students receive from a developmentally-appropriate approach to technology integration, they cannot fully reap those benefits without the guidance of teachers who are trained in technology use and integration. To properly facilitate the effective use of technology in the early childhood classroom, teachers need to complete extensive training which addresses not only their computer knowledge and skills but also their attitudes and instructional methods [Chen & Price, 2006].

Unfortunately, technology training in early childhood education is often unsuccessful for several reasons. First, training sessions are usually too short. A half or full-day in-service program provides little time for teachers to master even basic computer skills, let alone learn how to evaluate educational software and blend it with classroom activities. Chen and Chang [2006b] found that teachers who participated in technology training sustained over time were more confident and skilled at using the computer and designing instruction, compared to teachers who had less than a week of training. Second, technology coordinators or software demonstrators may be experts in technology use but lack knowledge about early childhood education. Therefore, classroom teachers learn how to use the technology but receive no instruction on integrating it with curriculum. Finally, technology training tends to focus on the upper elementary and secondary grade levels, which neglects the needs of young children and frustrates their teachers [Clements & Sarama, 2003; National Association for the Education of Young Children, 1996].

Frustration can turn to negativity very quickly, leading many teachers to abandon their plans to incorporate technology in the classroom. However, “the problem is not
negative attitudes. Faced with uncertainty and new demands, these feelings are understandable. Problems occur when training programs do not attend to teacher attitudes and do not support teachers in becoming comfortable and confident about computer use” [Chen & Price, 2006, p. 404]. Concerned with the lack of focus on teacher attitudes in most professional development programs today, Chen and Chang [2006a] developed the Whole Teacher Approach to Professional Development. The approach is multidimensional—addressing not only the computer skills that early childhood educators need to integrate technology into their curricula, but also their attitudes and practices. As Gimbert and Cristol [2004] assert, “The focus must be on learning to teach with technology rather than learning about technology” [p. 208]. The Whole Teacher Approach is also subject-specific. For example, a teacher integrating technology into a music class would have different attitudes, skills, and practices than a teacher who was integrating technology with early literacy.

Besides being multidimensional and subject-specific, the Whole Teacher Approach is both integrated and developmental. Chen and Chang [2006a] designed their approach to be integrated, based on the research of Vartuli [2005] who found that building teacher confidence put teachers in the right frame of mind to develop skills while, at the same time, motivating them to implement new practices. They also studied the research of others [Berliner, 1988; Eraut, 1994; Huberman, 1989] and decided that the Whole Teacher Approach should be developmental. Developmentally appropriate practice does not just apply to early childhood educators. Technology trainers also have to consider the different knowledge and skill levels that teachers are bringing to professional development programs. Therefore, Chen and Chang’s [2006a] Whole
Teacher Approach to Professional Development “facilitates the full range of teacher development supporting growth from novice to expert levels of proficiency. Working on different developmental levels, the same professional development experiences are not appropriate for all teachers. To be appropriate, experiences must be matched to the level, needs, and interests of teachers” [para 10].

Chen and Chang’s [2006a; 2006b] research in the area of professional development for early childhood educators supports the work of Sandholtz, Ringstaff and Dwyer [1997] who conducted a ten-year study with the Apple Classrooms of Tomorrow project and found that teachers go through three distinct phases of using technology in the classroom. First, they learn technical procedures. Then, they begin to use technology to support their current curriculum. Finally, their experience with technology makes them rethink how they teach. At this point, teachers are integrating technology with curriculum at its most effective level.

In conclusion, effective professional development programs for technology integration in the early childhood classroom should include the following characteristics:

1. Training programs should be lengthy and ongoing.
2. Trainers should be knowledgeable in the field of early childhood education.
3. Training programs should be catered to the early childhood curriculum. (What works for upper elementary and secondary education does not always work for younger children.)
4. Training programs should be multidimensional—focusing on teacher attitudes, knowledge, skills, and practices.
5. Training programs should be subject-specific. (Technology integration in math calls for different skills and strategies than technology integration in art.)

6. Trainers must first build teacher confidence before they can teach them to implement new practices.

7. Trainers must be aware of the different knowledge, skill levels, needs, and interests that teachers bring to the table.

A professional development program based on these seven principles has the greatest likelihood of improving student achievement and teacher quality. Gimbert and Cristol [2004] agree that well-planned technology training in the early childhood education setting benefits both students and teachers. “While young children learn in meaningful ways, their teachers learn as well—in ways that will have a long-term impact on infusing technology into their curriculum and/or teaching practices” [p. 214].

Family Literacy and Involvement in Technology Use

A good family literacy program can have the same effect as a good professional development program—both adults and students learn. The International Reading Association awarded its 2007 Presidential Award for Reading and Technology to Larry Ferlazzo, an English teacher from an inner-city high school in Sacramento, California. Ferlazzo started an after-school Computer Lab to help Hmong students learn to read and write English. (The Hmong are a group of people from China and Southeast Asia who helped the United States during the Vietnam War. There are currently 2,000 school-aged Hmong children living in the Sacramento area.) Ferlazzo also maintains a web site with free access to animated stories and links to thousands of activities for English language learners of all abilities. Hmong students who participated in his program saw a thirty-
three percent greater increase in their reading assessment scores than those students who chose not to participate. Because of Ferlazzo’s success, his school district was able to obtain a grant to start a family literacy project which includes in-school events where children show their parents how they learn to read, write, and speak English by using the Internet. In addition, Ferlazzo’s district provides literacy instruction for parents, organizes meetings in students’ homes to share creative literacy activities, and gives Internet-capable computers to participating families [Family Literacy Project, 2007].

Since obtaining the grant, the Sacramento school district has seen its family literacy program triple in size. Ferlazzo claims, “The key to the success of the project is that we use technology to help our students and their families deepen face-to-face relationships, not just relationships with the computer screen. In the Computer Lab, students from different ethnic groups do projects and play language games in groups and in pairs, and at-home families can read stories together” [Family Literacy Project, 2007, p. 45].

Obviously Ferlazzo has enjoyed great success with his innovative, technology-integrated family literacy program. But why extend literacy instruction into the home? Why not just teach children how to read, write, and speak English at school? According to the National Center for Family Literacy (NCFL) [2006], twenty percent of children five years old and under live in poverty in the United States. The parents of these children lack the resources they need, such as books, magazines, newspapers, and computers, to reinforce literacy skills at home. Children who live in poverty-stricken homes will hear thirty-two million fewer words by the time they are four than children who live in middle or upper-class households. Many low-income parents are either illiterate or have very
limited literacy skills. In fact, there are thirty million adults in the United States who
either cannot read and write or struggle to do it every day. Unfortunately, children whose
parents are functionally illiterate are twice as likely to be functionally illiterate
themselves [NCFL]. For these reasons, it is crucial that more schools start family literacy
programs like the one Larry Ferlazzo began in his Sacramento school district.

The following are recommendations for parents who want to engage in
technology literacy education at home:

- Demonstrate personal interest in the use of the computer.
- Be attentive to your child’s needs but allow him/her to explore new
technology independently.
- Expect technical problems.
- Create a library of software at home or borrow software from a library to
allow your child to explore.
- Provide challenging software that builds confidence and keeps your child
engaged.
- Ensure successful experiences with technology by choosing software that
is age and ability-level appropriate [Chatel, 2003].

Although these are good suggestions for parents who can afford to purchase a computer
and software for their children, there is nothing in this list that applies to low-income
families. Without family literacy programs that provide computers and software to poor
families, the digital divide will continue to grow.

Hispanics are the largest growing minority population in the United States with
the highest high school dropout rate. Two in five Hispanics who live in the United States
and are age twenty-five or older are high school dropouts [NCFL, 2006]. Most of their children will be illiterate and will never benefit from the use of technology that teaches literacy. The Migrant Educational Technology Program (MET) is an after-school program similar to Ferlazzo’s that allows children from Latino migrant families to borrow and take home computers and literacy software. The program also provides technical support for home use of the computers. The migrant families experienced project-based learning through the MET program. They were instructed to design a driving question and engage in extended inquiry through collaboration, cognitive learning tools, and artifacts. Teachers found that both parents and students improved their Spanish and English literacy skills through the program. All participating family members were dedicated to the program goals. One teacher said, “These developments speak to the program’s collective orientation—a sense of affiliation among the participants and myself along shared goals, values, and struggles. We all tried to become bilingual, which formed a bond among participants” [Carrillo, 2004, p. 174].

Another study of Hispanic family literacy examined the everyday lives of seven Dominican families in New York City. The researcher discovered that the following daily events, which were taking place in all seven of the homes, centered around literacy: reading the mail, reading and responding to information provided by institutions such as banks, employers, etc., reading and writing to complete the parents’ or children’s homework, and reading for pleasure. She also found that the Dominican mothers really wanted to learn to help their children with homework. It was suggested that family literacy programs take advantage of parent interests and day-to-day home literacy practices. It was also suggested that family literacy programs use the parents’ expertise in
reading, writing and speaking Spanish as a “springboard” for developing reading, writing, and speaking skills in English. Finally, the researcher stressed the need to incorporate the computer and the Internet into literacy programs for Dominican families not just to develop literacy skills, but to provide them with access to popular culture and a means by which they can educate themselves and become advocates for their families [Rodriguez, 2004].

A study of seventy-nine early childhood classrooms in Australia found that teachers failed to recognize the importance of technology and pop culture in literacy instruction. Despite their economic disadvantage, the parents of the children in these seventy-nine classrooms were well aware of the advantage computers and the Internet would provide their children [Makin, Hayden, & Diaz, 2000]. This shows a disconnect between home and school that might be reconnected through a good family literacy program. By working together, parents and teachers can use technology to develop literacy skills in young children. The more school districts provide parents with access to technology, the more educated they will become in literacy instruction. And the more parents become educated in literacy instruction, the more proficient their children will become at reading, writing, and speaking English. As a result, children will build their confidence, experience more successes, and be motivated to stay in school.

CONCLUSION

This review of research was conducted to answer questions that relate to issues surrounding the use of technology in early childhood education; technology use that promotes student learning outcomes in the early grades; developmentally appropriate and effective ways that technology is used to enhance the learning experiences of young
children; and the supports that early childhood professionals need to be able to effectively utilize technology in early childhood settings.

The review reveals evidence of a debate regarding the role that technology plays in early childhood education; however, a general consensus exists among the studies that support its use. Technology must be used in a developmentally appropriate manner in order to have a positive effect [Fischer & Gillespie, 2003] and meet the individual needs of children, birth though age eight. By allowing children to use technology in ways that are open-ended and flexible, creative and critical thinking skills are promoted. Based upon the literature reviewed, future research should address effective strategies for professional development and determine ways to gain funding for more access to technology. For example, involving early childhood faculty in grant writing endeavors and partnerships with universities may be two options to pursue.

It is necessary for early education professionals to stay abreast of current technology applications, such as CD and DVD burning and podcasting [Skouge et al., 2007] because these activities “are already being embraced by the world’s youth culture” and we should “form partnerships with youth to harness their energy in celebration of books and developing literacy” [p.11]. It is essential for early childhood professionals to connect with their students, families, and communities to continue to meet their students’ individual needs and not be outpaced by what technology has to offer in the “real world.” The classroom experiences of young children should mirror the “real world” of technology rather than highlight a disconnect between the two. Issues that relate to funding and access, along with professional development, must keep pace with the ever-evolving and changing world of technology.
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