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Techno-Tykes

Digital Technologies in Early Childhood

Marina Umaschi Bers and Elizabeth R. Kazakoff
Tufts University

During the last decade new technologies have been playing a major role in the lives of young children. The focus of this chapter is on how these new technologies are having a positive impact on children's learning and development and how young children, ages 2 to 7, are making use of those technologies in different contexts. While some researchers have written about the negative impact of new technologies in early childhood (see Cordes & Miller, 2000), this chapter focuses on the positive aspects. To that end, we explore the use of new technologies in early childhood through the Positive Technological Development (PTD) framework (Bers, 2006; Bers, 2010). PTD is a natural extension of the computer literacy and technological fluency movements that have influenced the world of education (Pearson, Greg, Young, & Thomas, 2002), but it adds psychosocial, civic, and ethical components to the cognitive ones, which have a strong presence in the disciplines that study human development (Bers, 2008).

PTD examines the developmental tasks of a child growing up in our digital era, and provides a model for developing and evaluating technology-rich youth programs. The explicit end goal of PTD programs is not to teach children to use technology to accomplish a task, as the computer literacy movement does; neither is it solely focused on helping young children to design and program their own meaningfully interactive projects, as those who seek technological fluency do (Bers, 2010). Rather, the goal is to mentor children in the positive uses of technology so they can have more fulfilling lives by making the world a better place (Bers, 2006).

New technologies are changing the developmental landscape for young people. The goal of this chapter is to inform and inspire educators, parents, and influential adults in children's lives to use technology with young children in developmentally appropriate ways.

New Technologies

We define new technologies as emerging digital tools that involve cutting-edge developments. New technologies in early childhood come in various forms and platforms such as computer-mediated software programs, video/audio learning instruments, robotic building kits, electronic toys, handheld and mobile devices, and sensors embedded in everyday objects. New technologies can engage a child playing by herself or can involve multiple children; they can be used as standalone devices, connected to the Internet, or integrated into classroom curriculum. New technologies make possible different kinds of learning opportunities, new ways for peer social interactions, and many possibilities for creativity, social, and cognitive development.

The history of technological devices has changed dramatically in the past 40 years, thanks to less expensive and more powerful batteries, LCDs, touch screens, and increased memory. Children now have access to cell phones, digital cameras, digital book readers, digital media players, and smart toys (Buckleitner, 2009). Current and future generations will grow up surrounded by these new technologies and others we have yet to imagine. Parents and teachers have a duty to raise and educate children to become digitally intelligent in addition to mastering the classic school subjects (Prensky, 2008 as cited in Buckleitner, 2009).

The children born in the 1990s are the first generation of children entering Piaget's stage of formal operations, described by the ability to think in a logical and abstract way (Piaget & Inhelder, 1969), with access to new technologies, such as smart phones and YouTube. They have their e-mail and social networking programs, such as MySpace, Facebook, and Twitter all in their pockets. The class of 2012 is the first group to come to cognitive maturity with the new digital technologies of today (Buckleitner, 2009). Young children are coming of age surrounded by new technolo-

gies that will be prominent forces in their lives (Berson & Berson, 2010). Research is needed to understand the impact of these new technologies on the development of children and how children are using and appropriating these tools in their own ways.

Young children learn in different ways from older children or adults. For example, children in Piaget's sensorimotor to preoperational stages may understand concrete concepts, but abstract ideas such as symbolic representations, are more difficult for them to grasp (Elkind, 1986; Piaget & Inhelder, 1969). New technologies have the potential to bridge these gaps. An iPhone, for example, allows for easy transition between multiple representations of a concept. A child can see a picture of an animal and the spelling of its name; while hearing the sound of the word and the sound the animal makes, all from the same device (Buckleitner, 2009).

Widespread Use of New Technologies

Children are exposed to new technologies before ever making it to their preschool classroom. Even if parents are not handing over their iPad, there are still digital technologies everywhere—from sinks that "know" where little hands are to the GPS in their parent's car. Due to the ubiquitous nature of new technologies, some parents have begun to revisit the American Academy of Pediatrics (1999) recommendation of no screen time at all before the age of 2 as they believe that their children will need to be digitally literate and computer savvy to succeed in the 21st century (Calvert, Rideout, & Woolard, 2005). According to a 2007 Kaiser Foundation study, 70% of parents of children younger than 2 years of age allow their children screen time (Vanderwater et al., 2007).

Whether children are formally introduced to new technologies through parents or just encounter them in their surroundings, they are a large part of young children's lives and, therefore, important to study. Currently, 75% of U.S. households have broadband Internet access (Pew Research, 2010a), 93% of children 6 to 9 live in a home with a cell phone (Sesame Workshop, 2007), 19% of children grades K-2 have access to a smartphone with Internet connectivity, 53% have access to a desktop computer, 31% to a laptop, and 32% to an mp3 player (Project Tomorrow, 2009). Twenty-seven percent of 5- to 6-year-olds use a computer, for an average of 50 minutes per day (Vanderwater et al., 2007).

A gap in computer access has developed, however, between African American and rural households and European American households. Only 56% of African American adults have broadband in the home and only 50% of rural households do so (Pew Research, 2010a). Increasingly, Internet connectivity for these groups, and people across the globe, comes in the form of mobile technologies (Shuler, 2009b. In 2010, 64% of African Americans accessed the Internet from their mobile phone, and cell phone ownership among African Americans and Latinos is higher than among European Americans (87% vs. 80%; Pew Research, 2010b).

Cell phone use is quickly becoming ubiquitous. More than half the world's population owns a cell phone. Children under 12 are the fastest growing group of mobile technology users (Shuler, 2009a). Between 2005 and 2008, mobile device ownership among children ages 4 to 14 doubled (NPD Group, 2008). Cell phones are cheaper, easy to transport, and easier to repair than traditional computers, which has led to their rapid growth in countries outside the United States. Whereas Americans tend to own multiple devices, people in many other countries access the Internet exclusively by cellular devises (World Economic Forum, 2010).

With cell phones, come apps (mobile applications). Almost half of the 100 best-selling apps for smartphones (47%) in 2009 were designed for preschool and elementary aged children; by April 2009, there were already 21,000 app games for young children compared to just a couple hundred for Nintendo DS or Playstation PSP (Shuler, 2009b). Thirty-five percent of apps are aimed at preschool children and, of the top 25 apps, over half of those are designed for the preschool age group (Shuler, 2009a). The most popular areas are early literacy, foreign language, and math, costing between 99 cents and $2.99. The low cost of these apps and the widespread availability of mobile devices, make apps a key area of development for educational material in the coming years (Shuler, 2009a, 2009b).

Early childhood is a time when children learn about their world and how to interact with it socially, and now, digitally. Children spend almost as much time with digital technologies as they do learning in school, leading to an opportunity to leverage these technologies (Shuler, 2007). Thus, we should ask ourselves not only what kinds of technologies are young people using, how often, and in what context, but most importantly, what are young children doing with these technologies. Are they using them in a way that is consistent with developmentally appropriate practice? Are children being supported by these technologies so that they engage in the developmental tasks appropriate for their age?

Interactive Fears

Through the centuries, the invention of all new technologies has been associated with a consistent fear regarding the impact that new technology will have on children. This fear happened with the invention of books, movies, radio, and now the Internet and mobile devices. However, one of the differences between the old concerns and the new ones is the interactive nature of digital technologies (Wartella & Jennings, 2000).

In the digital world, children not only consume but can also create content and interact with others. The increased interactivity can yield a potential benefit but it can also be harmful. On the one hand, with digital media, it is harder to protect children from accessing negative advertising, violent, or sexual content. Unlike television, there is less

...[control ove]r the online content (Belvins & Anton, 2008). [Young] children who are not yet cognitively developed past [the preop]erational stage might have trouble differentiating [between] what is programming versus advertising and what [is real vers]us make-believe, which can be troublesome when [viewing] digital media (Piaget & Inhelder, 1969; Troseth, [2003). Y]oung children may also lack the vocabulary neces[sary for i]nsightful, metacognitive, evaluative explanations of [their own] behavior and may lack the ability to communicate [about the] content they are exposed to or their reactions to [the conten]t (Fleer, 1999).

[Earl]y on, Elkind (1986) argued that technology could [amplify] a young child's limitations in thinking. For exam[ple, he s]uggested that even though young children who were [exposed] to the Logo programming language could learn the [sequenc]es necessary for creating a computer program, they [did not] have yet the cognitive capacity to understand the [motion] of the computer cursor. This lack of fundamental [basic u]nderstanding could then lead to distress.

[In ad]dition, arguments previously made about television [are simi]lar to arguments made today about the Internet. [Some] researchers believe that rapid access to information [and doz]ens of links to click online may be limiting human [abilitie]s to read deeply and concentrate and that there are [fundam]ental brain changes occurring when we read infor[mation] online (Carr, 2010; Small & Vorgan, 2008; Wolf, [2007). I]n 1986, Elkind also proposed that the rapid intro[duction] of concepts on screen (i.e., *Sesame Street*) could be [contrib]uting to children's attention difficulties. With each [new] technology, similar concerns persist.

[The] digital world also brings about some new concerns, [particu]larly around mobile technologies. There are concerns [regard]ing the impact on physical health, the difficulty in [monito]ring activity, the potential for distraction, and the [compl]exity of using the keyboards for children whose fine [motor] skills have not yet fully developed. Eighty-five per[cent of] teachers surveyed by the Sesame Workshop in 2008 [believe] cell phones have no place in schools. This response [was c]onsistent even among teachers in their early 20s, who [had g]rown up with cell phones (Shuler, 2009a).

[The] primary concern surrounding new technologies and [children] relates to the free accessibility provided by tools [such] as the Internet. This accessibility might mean access [to m]isinformation, pornographic and violent online content, [adver]tising, and communication with potentially danger[ous] people. Concerns also persist around the computer as a [source] of isolation for children (Cordes & Miller, 2000) and [a repl]acement for other activities (Bus & Neuman, 2009), [particu]larly those involving physical activity.

Positive Use of Technology: The PTD Framework

[From] a theoretical perspective, PTD integrates ideas from [the fie]lds of computer-mediated communication, computer-[sup]ported collaborative learning, and constructionist [learning] through technology, with research in applied de-

velopment science and positive youth development. PTD focuses on positive behaviors supported by the technology and how those behaviors can, in turn, promote positive development (Bers, 2010).

Research on PTD, a framework that guides the design of technologically rich educational programs for children and teenagers, has shown technologies that support positive development and engage youngsters in the following activities (Bers, 2006, 2010):

Content Creation

The most powerful way in which children can use new technologies is to create personally meaningful projects. In the same way that young children use paintbrushes and clay to make art projects, technologies provide a new medium, programming tools, to add interactivity to their creations. Although young children are not developmentally ready to engage with sophisticated programming tools, research has shown that, when presented with developmentally appropriate interfaces, children as young as 4 years old can use different technologies to make their own projects come alive (Bers, 2008; Bers et al., 2006; Bers & Horn, 2010; Johnson, 2003). Children are not merely consuming information technology; they take an active role in creating, manipulating, and disseminating information (Berson, 2003).

Through the process of content creation, children develop *competence* regarding 21st century skills such as digital literacy (Ba, Tally, & Tsikalas, 2002; Karlstrom, Cerratto-Pargman, & Knutsson, 2008; McMillan, 1996;). Twenty-first century literacy means connecting digital dots, across media, including areas yet to be developed (Jones-Kavalier & Flannigan, 2008), and gaining skills in areas beyond the traditional subjects of reading, writing, and arithmetic. Twenty-first century skills include literacies in media, information, and communication technologies; in global awareness and in finance, business, entrepreneurship, and civic engagement (Wang, Berson, Haruszewicz, Hartle, & Rosen, 2010).

Technologies that enable children to become programmers can be powerful tools for teaching old and new skills and concepts (Bers, 2008; Clements, 2002; Papert, 1980), especially those related to problem solving and early math skills. For example, a large scale study of children using the Logo programming language demonstrated that children in grades K–6 scored significantly higher on mathematics, reasoning, and problem-solving tests (Clements, Batista, & Sarama, 2001). In addition, children can learn skills beyond those directly related to technology. Kazakoff and Bers (2010) found that kindergarten aged children who participated in computer programming workshops showed statistically significant gains in sequencing skills. These skills are foundational not only to mathematics and programming, but also to early literacy.

In order to create content, children engage in a design process which, like the scientific method, invites them to

problem-solve. The kinds of technologies that promote content creation tend to belong to the family of constructionist learning environments that offer children tools to construct open-ended projects (Resnick, 2006; Resnick, Bruckman, & Martin, 1996), such as programming languages for children, or hands-on materials and manipulatives, such as building blocks and robotic construction kits (Bers, 2008). These constructionist technologies are in contrast with those belonging to the family of computer-assisted instructional instruments that use a drill and practice approach (such as computer software that teaches numbers and vocabularies that are commonly used in early childhood). Some examples of drill and practice software are

Math Blaster ® (www.knowledgeadventure.com/
  mathblaster/),
Millie's Math House (Edmark, 2005)
Bailey's Book House (www.edmark.com).

There are very few tools explicitly designed for young children to create content in a constructionist way. Examples include

KidPix (http://www.mackiev.com/kid_pix.html)
Robotics construction kits such
Lego® WeDo® (http://www.legoeducation.us) and
  CHERP (http://ase.tufts.edu/DevTech/tangiblek/
  research/cherp.asp)
Logo (http://www.microworlds.com/solutions/mwju-
  nior.html)

In addition, simply using digital cameras and voice recorders can allow children to create their own movies, stories, and slide shows. Digital cameras and audio recorders can be used to help children go beyond their egocentric thinking, allowing them to hear and see their surroundings and the people and objects in their world (Ching, Wang, & Kedem, 2006). Children interact with these tools in their households and are familiar with their function. Research needs to be conducted in order to create a powerful curriculum for their use and further integration into classrooms.

Creativity

New technologies that integrate multimedia tools allow children to generate new ideas and express them in innovative ways. Information and communication technologies incite creativity (Berson & Berson, 2010). Despite worries that computers stifle creativity, research has found that when used well, computers actually can help creativity bloom (Clements & Sarama, 2003). When children are engaged in creating their own computer-based projects and, in the process, find themselves solving technical problems in creative ways, they start to develop a sense of confidence in their learning potential.

Thus, in early childhood the most promising technologies are those that invite creativity and the exploration of different strategies as opposed to efficiency in problem solving. For example, when a 4-year-old uses KidPix to create a story and animates the characters with motion and music and then presents a slideshow to her parents, or when a 5-year-old uses the CHERP (Bers & Horn, 2010) robotic programming language to make animals that can dance and move around in search of food, technology is opening a door to creativity (Bers, 2008; Johnson, 2003).

By combining recyclables and traditional art materials with technological components, young children can take a robotic base and turn it into anything they want; from a monster truck to a kitty cat to a flower for an interactive garden (Bers, 2008; Bers, Ponte, Juelich, Vietra, & Schenker, 2002; Rusk, Resnick, Berg, & Pezalla-Granlund, 2008). Robots are not just creatures such as Wall-E and R2D2, robotics can be a creative play space for storytelling, self-expression, and cultural awareness. Basic computer programs, such as Microsoft Paint or PowerPoint afford children opportunities to draw and manipulate objects and pictures. Music software can provide children with a medium for creating their own music, beyond using sometimes limited and expensive musical instruments.

Computers can be programmed so they can be anything to anyone, taking on a "thousand forms" for a "thousand functions" and appeal to a "thousand tastes" (Papert, 1980). This is the power of digital technology as an educational and artistic tool.

Collaboration

Research has shown that computers might instigate new forms of collaboration among young children, such as helping and instructing behaviors, discussion, and cooperation (New & Cochran, 2007). Different types of technologies are specifically designed to promote social interaction among users and may be used in a context that facilitates positive peer interaction. Children engage more frequently at turn taking, cooperative play, and language use at a computer than when using puzzles and blocks (Genishi, McCollum, & Strand, 1985). Children also prefer to work in teams rather than individually when using computers. Furthermore, computers allow for collaboration via e-mail, electronic field trips, and video conferencing with other classrooms; social interactions that were previously not possible due to physical location (National Association for the Education of Young Children [NAEYC], 1996).

For young children who are in the developmental process of learning how to work with others, the design features of the technology might promote social and prosocial development. Classic developmental theorists such as Piaget (1928) and Vygotsky (1978) both discussed the influence of children on one another in furthering cognitive development. Early childhood is a time of egocentrism. Collaboration with other children while using technology may help to foster interactions between peers who would otherwise be focused

on their own thoughts and might lead to a child engaging in partnerships that involve her or his zone of proximal development. For example, a child who is better skilled at using the mouse or browsing the Web might work together with a child who has had less exposure to the technology; a child who has used a digital camera at home might show another child which button to press, and children may show each other their favorite smartphone apps and instruct one another on initial play instructions. Research shows that there is more spontaneous peer teaching and helping at a computer screen than during other classroom activities (Clements & Nastasi, 1992).

New technologies also have the benefit of being smaller, from netbooks to iPhones. Computers no longer fill entire rooms! This size element enables a child to easily collaborate with others. A piece of technological equipment can be easily picked up and brought across the room to a friend, teacher, or parent. This also gives the child the opportunity to move her body; there is no need to just sit at a computer. Children can make their own songs and videos to dance to, or act out the actions of their robots. Children can carry the laptop to show off their work to anyone around them or they can climb onto dad's lap to explore an iPad app with him. The mobility of new technologies lends itself to interactions.

Communication

Although in some cases the term communication is defined as an "exchange of data and information," when thinking about new technologies and young children, here we focus on communication as meaning the mechanisms that promote a sense of connection between peers or with adults. Technologies that effectively facilitate social interaction also promote language and literacy development. Activities around technologies that support interactions among peers by encouraging peer learning, peer teaching, and cooperation inevitably become venues for language-rich exchanges. At the computer, for example, research has shown that children speak twice as many words per minute than at other nontechnology related play activities such as Play-Doh and building blocks (New & Cochran, 2007) and speak to their peers nine times more than when working on traditional puzzles (Muller & Perlmutter, 1985). With mobile devices, children and parents can turn any moment, such as waiting in a doctor's office, or waiting in line at the grocery store, into interactive learning times. There are thousands of apps, ones for creativity and drawing (Brushes, Scribble), fun and education (Wheels on the Bus, Cute Math, Animal Match), ones that are just for fun (iPlayPhone, TicTacToe), and traditional stories (Dr. Seuss) that parents and children can explore together.

With products such as Skype, children are able to communicate face-to-face with their grandparents and loved ones. This can potentially eliminate the problems that arise when children, having not yet grasped object permanence (Piaget, 1954), try to engage in non-face-to-face communication. With Wikis, Web site, Google groups, and dozens of photo sharing programs, children's work and pictures from the day can be posted online, on password protected pages, for parents to view; thus bringing the classroom to the parents and providing the parent and child with many specific discussion points beyond "What did you do in school today?"

While even standalone drill and practice computer software can help children read and strengthen their vocabulary recall, the impact of technology is greatest with regard to language development when it is also used to facilitate peer interactions rather than as a replacement for teachers or tutors (New & Cochran, 2007). Research shows that when children are using computers, they are more likely to ask other children for advice and help, even if an adult is present, thus increasing socialization (Wartella & Jennings, 2002). Even in situations where each child has an individual computer or other piece of digital equipment to work with, children still choose to form groups (Druin, 1998). Children learn from each other and build communication skills by sharing, discussing, and asking questions about the new technologies they are using. They begin to move past parallel play to engage with the technology and each other. In addition, as children begin to explore virtual worlds (ex. Panwapa, Club Penguin) they utilize conversational scripts to continue learning about conversational patterns and communicating with others—the parent sitting next to them and the child across the globe. The growing trend of virtual worlds specifically developed for children is also having an impact in early childhood (Beals & Bers, 2009).

Community Building.

Early childhood education involves working both with the child on an individual basis, and with the child as a participant in her different communities. This challenge is also present in the theories that inform the design of technologies. For example, the Computer Supported Collaborative Learning (CSCL) paradigm (Koshmann, 1996) shifts the process of cognition as residing within the head of one individual to the view that cognition is situated within a particular community of learning or practice (Lave & Wenger, 1991). Therefore, educational technologies designed within this paradigm take seriously the need to provide tools for community building and community scaffolding of learning. This is well-aligned with the PTD framework (Bers, 2006) used to organize the ideas in this section. New technologies should promote children, even in early childhood, to see themselves as making *contributions* to the learning environment and their community. For example, new programming environments, such as Scratch (scratch.mit.edu) have vibrant online communities of sharing, contribution, and collaboration (Resnick et al., 2009).

In the spirit of the Reggio Emilia approach started by the Municipal Infant-Toddler Centers and Preschools of Reggio Emilia in Italy after World War II, new technologies

can encourage children's projects to be shared with the community via an open house, demo day, or exhibitions (Rinaldi, 1998), as well as by posting them online. This provides authentic opportunities for children to share and celebrate the process and products of their learning with family, friends, and community members.

Digital technologies allow us to be connected to the world at the click of a button. The children of the 21st century can communicate and collaborate both with the person next to them and someone across the globe. Community building and collaboration within and across cultures is a skill for young children to begin developing early, as it will be essential in their futures (Wang et al., 2010). Panwapa (http://www.panwapa.org/) developed by Sesame Workshop is an example of an online network to connect young children across the globe and so that they can learn about a variety of cultures, including their own.

Choices of Conduct

From a moral development standpoint, early childhood is a time of egocentrism and an early development of perspective taking. It is around this time that children begin to understand the concept of fairness (Colby & Kohlberg, 1987). New technologies may support this process by providing children with the opportunity to experiment with "what if" questions and potential consequences, and to provoke examination of values and exploration of *character traits*. Most explorations of the moral and ethical domain though new technologies happen later on, when children are avid users of the Internet and might face cyberbullying (Li, 2006, 2007) and the temptations of piracy (Chiou, Huang, & Lee, 2005; Logsdon, Thompson, & Reid, 1994). However, it is never too early to being teaching and modeling appropriate cybersafety and "netiquette" to young children (Berson & Berson, 2004; Shea, 1994; Straker, Pollock, & Burgess-Limerick, 2006). Virtual communities designed for young children, such as

Panwapa (http://www.panwapa.org/) and
Disney's Club Penguin (http://www.clubpenguin.com/)

do have safety features built in, such as preset chat scripts. These begin to provide models for appropriate behavior. Web sites, such as Webkinz (http://www.webkinz.com/) provide an opportunity for children to learn about taking care of pets and also integrate a social networking component. In addition, Webkinz integrates a physical component (stuffed animal) with the virtual world. However, sites such as Webkinz have been criticized for promoting consumerism, consumptionism, and competition (Dellinger-Pate & Conforti, 2010).

While the Internet is a natural playground for exploring issues of character, other new technologies might also be used with this purpose. For example, in our work with robotics and kindergarten-aged children, special attention

is paid to helping children explore personal and moral values by placing them in situations that invite them to make a conscious choice of conduct (Bers, 2008). For example, most robotic programs give each group of children an already sorted kit with all the LEGO building pieces and other materials to build a robot. On our work on the TangibleK program we take a different approach. We sort all materials by types and placed them in bins in the center of the room (instead of giving an already sorted robotic kit to each child or group). Thus children learn how to take what they need without depleting the bins of the "most wanted" pieces, such as special sensors or the colorful LEGO minifigures. They also learn how to negotiate for what they need. Our TangibleK program, inspired by the PTD philosophy, focuses not only on learning about robotics but also on helping young children develop an inner compass to guide their actions in a just and responsible way (Bers, 2010).

Future Directions

Children are growing up surrounded by technology but little is known about what impact this has on their learning and development. The public discourse regarding new technologies tends to group them altogether and disregard the design affordances of each of them and what developmental tasks they are best matched at supporting and enhancing. Computer games do not necessarily impact a child in the same way as an iPhone app, a robotic toy kit, technologically enhanced book, or a programming environment. Each new technology must be independently researched. What may be true for a computer is not necessarily true for an iPad and vice versa. We must be careful not to assume that all screens are created equal.

Research indicates new technologies, such as cell phone apps, may have a positive impact on vocabulary and literacy skills in 3 to 7 year olds (Chiong & Shuler, 2010). Developmentally appropriate computer programming in early childhood has also shown a positive impact on sequencing skills (Kazakoff & Bers, 2010) and computer use has shown positive impact on cognitive abilities such as abstraction, problem solving, and structural knowledge (Clements & Sarama, 2002; Haugland, 1992; Wang & Ching, 2003). Bers's work has also explored how, when presented with a developmentally appropriate interface, such as a tangible programming environment, kindergarteners can understand powerful computational ideas such as sequencing, control flow, loops, and branches and develop sophisticated levels of computational thinking (Bers, 2008; Bers & Horn, 2010; Bers et al., 2002).

Research is mixed on the integration of technology into conventional storybooks (Bus & Newman, 2009). Commercially available products for young children, such as LeapFrog's Tag Reading System help to digitally scaffold young children's reading comprehension strategies and encourage engagement in reading by asking questions of the reader that reinforce the storyline and character develop-

tent (Gray, Bulat, Jaynes, & Cunningham, 2009). Books embedded with technological and interactive components have also been found to be distracting when animations and interactive components are not part of the storyline. These distractions may negatively impact comprehension of the story (Labbo & Kuhn, 2000).

We are in dire need of additional research to be conducted on the impact of new technologies on learning, personal-social development, and attention in early childhood. There is a body of research on the impact of television on young children (see Moses, 2008; Thakkar, Garrison, & Christakis, 2006, Uchikoshi, 2009 for a review) but not much for the new technologies, especially in regard to early childhood or the differences between new technologies. There are many unanswered questions, such as: What impact are new technologies having on early childhood education? What will young children need to know in order to be digitally literate and successful in the 21st century and beyond? What do children know about the technological worlds around them? What are the long term implications of growing up in the digital age? How can we create developmentally appropriate curricula for studying new technologies, such as laptops, cell phones, video recorders, cameras, to name a few, in order to ensure children can navigate the digital world and adapt to future technologies yet to be invented? Or, perhaps more importantly, How do we adequately prepare our children to be the people who create the future of technology and compete in a global economy?

Conclusion

Our forefathers believed children could not learn to read before age 6 or 7 (Hall, Larson, & Marsh, 2003), and we must not make the same assumptions about digital literacy. Historically, from 1883 when the word *literacy* first appeared in the dictionary until the late 1970s/early 80s it was believed children could not learn to read until ages 6½ or 7. Eventually, psychologists began to realize that children were certainly learning about words, letters, and language earlier than the point when they entered formal school because they were growing up surrounded by print, newspapers, billboards, and books.

The same holds true for new technologies. Children are exposed to the digital world continuously; it is part of their environment just like billboards, newspapers, books, and magazines. The time has come to challenge historical assumptions of what is developmentally appropriate and start teaching young children the skills they need to know to understand the world around them, a world that is increasingly more digital every day.

Although some uses of new technologies have come into the early childhood classrooms, they have not necessarily produced the expected outcomes. Too quickly they are becoming "oversold and underused" (Cuban, 2001). While these tools have the potential to enhance learning, Papert (1987) reminds us of the dangers of falling into the tech-

nocentric fallacy, the assumption that technology by itself can produce changes. New tools are only one of the many elements of the social and cultural context in which learning takes place and it is naïve to expect to introduce a new element and observe change resulting in the entire system.

The technocentric fallacy has largely permeated the past and present of educational technology. For example, research has found that, despite the nationwide large investment in new equipment and wiring of public schools, most of the computers "end up being souped-up typewriters" used in unimaginative ways (Cuban, 2001).

Technology is such an integral part of a child's daily life that learning environments without it are out of touch with a child's reality (Berson & Berson, 2010). However, teachers are not well prepared to know how to effectively integrate technology into the curriculum, how to craft developmentally appropriate technology-rich programs, or how to rethink the curriculum in the light of new technologies. These problems are in part due to the technocentric approach that puts too much emphasis on the technology and very little on the conditions in which the technology will be used. Making it possible for educators and children to use computers expressively and in creative ways involves not just the deployment or development of new tools, but also a framework to provide social support for learning and new supporting structures at both the micro- and macrolevels of the educational system, thus, our choice to organize this chapter on the positive impact of new technologies on early childhood around the PTD framework.

References

American Academy of Pediatrics. (1999). Media education. *Pediatrics*, *104*, 341–342.

Ba, H., Tally, W., & Tsikalas, K. (2002). Investigating children's emerging digital literacies. *The Journal of Technology, Learning, and Assessment*, *1*(4), 1–48.

Beals, L., & Bers, M. U. (2009). A developmental lens for designing virtual worlds for children and youth. *The International Journal of Learning and Media*, *1*(1), 51–65.

Belvins, J. L., & Anton, F. (2008). Muted voices in the legislative process: The role of scholarship in US Congressional efforts to protect children from internet pornography. *New Media Society*, *10*(1), 115–137.

Bers, M. (2006). The role of new technologies to foster positive youth development. *Applied Developmental Science*, *10*(4), 200–219.

Bers, M. U. (2008). *Blocks to robots: Learning with technology in the early childhood classroom.* New York: Teacher's College Press.

Bers, M. (2010) Beyond computer literacy: Supporting youth's positive development through technology. In *New directions for youth development: Theory, practice, and research* (pp. 13–23). San Francisco, CA: Jossey-Bass.

Bers, M. U., & Chau, C. (2006). Fostering civic engagement by building a virtual city. *Journal of Computer-Mediated Communication*, *11*(3), article 4. Retrieved from http://jcmc.indiana.edu/vol11/issue3/bers.html

Bers, M., & Horn, M. (2010). Tangible programming in early childhood: Revisiting developmental assumptions through new technologies. In I. R. Berson & M. J. Berson (Eds.), *High-tech tots: Childhood in a digital world* (pp. 49–70). Greenwich, CT: Information Age.

Bers, M, Ponte I, Juelich, K, Viera, A., & Schenker, J. (2002). Teachers as designers: Integrating robotics into early childhood education. *Information Technology in Childhood Education*, *1*, 123–145.

Bers, M., Rogers, C., Beals, L., Portsmore, M., Staszowski, K., Cejka, E, Barnett, M. (2006, June). *Early childhood robotics for learning*. Poster Session at the International Conference on the Learning Sciences. Bloomington, IN.

Berson, I. R. (2003). Making the connection between brain processing and cyberawareness: A developmental reality. *Proceedings of the Netsafe II: Society, Safety and the Internet Symposium*, Auckland, New Zealand.

Berson, M. J., & Berson, I. R. (2004). Developing thoughtful "cybercitizens." *Social Studies and the Young Learner, 16*(4), 5–8.

Berson, I. R., & Berson, M. J. (Eds.). (2010). *High-tech tots: Childhood in a digital world*. Charlotte, NC: Information Age.

Buckleitner, W. (2009). Pocket rockets: The past, present, and future of children's portable computing in mobile technology for children. In A. Druin (Ed.), *Designing for interacting and learning* (pp. 43–61). Burlington, MA: Elsevier.

Bus, A. G., & Neuman, S. B. (2009). *Multimedia and literacy development: Improving achievement for young learners*. New York: Routledge.

Calvert, S. L., Rideout, V. J., & Woolard, J. L. (2005). Age, ethnicity, and socioeconomic patterns in early computer use: A national survey. *American Behavioral Scientist, 48*(5), 590–607.

Carr, N. (2010). *The shallows: What the internet is doing to our brains*. New York: Norton.

Ching, C. C., Wang, X. C., & Kedem, Y. (2006). Digital photo journals in a K-1 classroom: A novel approach to addressing early childhood technology standards and recommendations. In S. Tettegah & R. Hunter (Eds.), *Technology: Issues in administration, policy, and applications in K-12 classrooms* (pp. 253–269). Oxford, England: Elsevier.

Chiong, C., & Shuler, C. (2010). *Learning: Is there an app for that?* New York: Joan Ganz Cooney Center at Sesame Workshop.

Chiou, J., Huang, C., & Lee, H. (2005). The antecedents of music piracy attitudes and intentions. *Journal of Business Ethics, 57*(2), 161–174.

Clements, D. H. (2002). Computers in early childhood mathematics. *Contemporary Issues in Early Childhood, 3*(2), 160–181.

Clements, D. H., Battista, M. T., & Sarama, J. (2001). Logo and geometry. *Journal for Research in Mathematics Education Monograph Series, 10*.

Clements, D. H., & Nastasi, B. K. (1992). Computers and early childhood education. In M. Gettinger, S. N. Elliott, & T. R. Kratochwill (Eds.) *Advances in school psychology: Preschool and early childhood treatment directions* (pp. 187–246). Hillsdale, NJ: Erlbaum.

Clements, D. H., & Sarama, J. (2002). The role of technology in early childhood learning. *Teaching Children Mathematics, 8*, 340–343.

Clements, D. H. & Sarama, J. (2003). Strip mining for gold: Research and policy in educational technology: A response to "Fool's Gold". *AACE Journal, 11*(1), 7–69.

Colby, A., & Kohlberg, L. (1987). *The measurement of moral judgment*. New York: Cambridge University Press.

Cordes, C., & Miller, E. (2000). *Fool's gold: A critical look at computers in childhood*. College Park, MD: Alliance for Childhood.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge, MA: Harvard University Press.

Dellinger-Pate, C., & Conforti, R.J. (2010). Webkinz as a consumerist discourse: A critical ideological analysis. In I. R. Berson & M. J. Berson (Eds.), *High-tech tots: Childhood in a digital world* (pp. 249–267). Charlotte, NC: Information Age.

Druin, A. (1998). *The design of children's technology*. San Francisco, CA: Morgan Kaufmann.

Edmark. (2005). Millie's Math House [computer software]. Redmond, WA.

Elkind, D. (1986). Formal education and early childhood education: An essential difference. *The Phi Delta Kappan, 67*(9), 631–636.

Fleer, M. (1999). The science of technology: Young children working technologically. *International Journal of Technology and Design Education, 9*, 269–291.

Genishi, C., McCollum, P., & Strand, E. B. (1985). Research currents: The interactional richness of children's computer use. *Language Arts, 62*(5), 526–532.

Gray, J. H., Bulat, J., Jaynes, C., & Cunningham, A. (2009). LeapFrog learning design: Playful approaches to literacy from LeapPad to the Tag Reading System. In A. Druin (Ed.), *Mobile technology for children* (pp. 171–194). Burlington, MA: Morgan Kaufmann.

Hall, N., Larson, J., & Marsh, J. (2003). *Handbook of early childhood literacy*. Thousand Oaks, CA: Sage.

Haugland, S. W. (1992). The effect of computer software on preschool children's developmental gains. *Journal of Computing in Childhood Education, 3*(1), 15–30.

Johnson, J. (2003). Children, robotics, and education. *Artificial Life and Robotics, 7*(1/2), 16–21.

Jones-Kavalier, B. R., & Flannigan, S. L. (2008). Connecting the digital dots: Literacy of the 21st century. *Teacher Librarian, 35*(3), 13–16.

Karlstrom, P., Cerratto-Pargman, T., & Knutsson, O. (2008). Literate tools or tools for literacy? *Digital Kompetanse, 3*, 97–112.

Kazakoff, E., & Bers, M. (2010). Computer programming in kindergarten: The role of sequencing, *ICERI2010 Proceedings*, 6086–6089.

Koshmann, T. (1996). *CSCL: Theory of practice of an emerging paradigm*. Mahwah, NJ: Erlbaum.

Labbo, L. D., & Kuhn, M. R. (2000). Weaving chains of affect and cognition: A young child's understanding of CD-ROM talking books. *Journal of Literacy Research, 32*(2), 187–210.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.

Li, Q. (2006). Cyberbullying in schools: A research of gender differences. *School Psychology International, 27*(2), 157–170.

Li, Q. (2007). New bottle but old wine: A research on cyberbullying in schools. *Computers in Human Behavior, 23*(4), 1777–1791.

Logsdon, J. M., Thompson, J. K., & Reid, R. A. (1994). Software piracy: Is it related to level of moral judgment? *Journal of Business Ethics, 13*(11), 849–857.

McMillan, S. (1996). Literacy and computer literacy: Definitions and comparisons. *Computers in Education, 27*(3/4), 161–170.

Moses, A. M. (2008). Impacts of television viewing on young children's literacy development in the USA: A review of the literature. *Journal of Early Childhood Literacy, 8*(1), 67–102.

Muller, A. A., & Perlmutter, M. (1985). Preschool children's problem-solving interactions at computers and jigsaw puzzles. *Journal of Applied Developmental Psychology, 6*, 173–186.

National Association for the Education of Young Children (NAEYC). (1996). *Technology and young children—Ages 3 through 8* (NAEYC Position Statement). Washington, DC: Author.

New, R. S., & Cochran, M. (Eds.). (2007). *Early childhood education: An international encyclopedia*, (Vol. 3). Westport, CT: Praeger.

NPD Group. (2008). *Kids and consumer electronics* (Vol. 4). Port Washington, NY: Author.

Papert, S (1980) *Mindstorms: Children, computers and powerful ideas*. New York: Basic Books.

Papert, S. (1987). Computer criticism vs. technocentric thinking. *Educational Researcher, 16*(1), 22–30.

Pearson, G., & Young, A. T. (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, DC: National Academies Press.

Pew Research. (2010a). *66%—Broadband adoption slows*. Pew Research Center, the Databank. Retrieved from http://pewresearch.org/databank/dailynumber/?NumberID=1070.

Pew Research. (2010b). Mobile access 2010. Retrieved from http //pewinternet.org/Reports/2010/Mobile-Access-2010/Summary-of-Findings.aspx.

Piaget, J. (1928). *Judgment and reasoning in the child*. London: Routledge & Kegan Paul.

Piaget, J. (1954). *The construction of reality in the child*. New York: Basic Books.

Piaget, J., & Inhelder, B. (1969). *The psychology of the child*. New York: Basic Books.

Project Tomorrow. (2009). *Speak up data*. Retrieved from http://www.tomorrow.org/speakup/speakup_your_data.html.

Resnick, M. (2006). Computer as a paintbrush: Technology, play, and

the creative society. In D. Singer, R. M. Golinkoff, & K. Hirsh-Pasek (Eds.). *Play = learning: How play motivates and enhances children's cognitive and social-emotional growth* (pp. 192–208). New York: Oxford University Press.

Resnick, M., Bruckman, A., & Martin, F. (1996) Pianos not stereos: Creating computational construction kits. *Interactions, 3*(6), 41–50.

Resnick, M., Maloney, J., Monroy-Hernandez, A., Rusk, N., Eastmond, E., Brennan, K…Kafai, Y. (2009). Scratch: Programming for all. *Communications of the ACM, 52*(11. 60–67.

Rinaldi, C. (1998). Projected curriculum constructed through documentation-Progettazione: An interview with Lella Gandini. In C. Edwards, L. Gandini, & G. Forman (Eds.), *The hundred languages of children: The Reggio Emilia approach—Advanced reflections* (2nd ed., pp. 113–126). Greenwich, CT: Ablex.

Rusk, N., Resnick, M., Berg, R., & Pezalla-Granlund, M. (2008). New pathways into robotics: Strategies for broadening participation. *Journal of Science Education and Technology, 17,* 59–69.

Sesame Workshop. (2007). *The media utilization study.* New York: Author.

Shea, V. (1994). *Netiquette.* San Francisco, CA: Albion Books.

Shuler, C. (2007). *D is for digital.* New York: Joan Ganz Cooney Center at Sesame Workshop.

Shuler, C. (2009a). *Pockets of potential: Using mobile technologies to promote children's learning,* New York: Joan Ganz Cooney Center at Sesame Workshop.

Shuler, C. (2009b). *iLearn: A content analysis of the iTunes app store's education section.* New York: Joan Ganz Cooney Center at Sesame Workshop.

Small, G., & Vorgan, G. (2008). *iBrain: Surviving technological alteration of the modern mind.* New York: HarperCollins.

Straker, L., Pollock, C., & Burgess-Limerick, R. (2006). Towards evidence-based guidelines for wise use of computers by children. *International Journal of Industrial Ergonomics, 36(*12), 1045–1053.

Thakkar, R. P., Garrison, M. M., & Christakis, D. A. (2006). A systematic review for the effects of television viewing by infants and preschoolers, *Pediatrics, 118,* 2025–2031.

Troseth, G. L. (2003). TV Guide: 2-year-olds learn to use video as a source of information. *Developmental Psychology, 39*(1), 140–150.

Uchikoshi, Y. (2009). Effects of television on language and literacy development, In A. G. Bus & S. B. Neuman (Eds.), *Multimedia and literacy development: Improving achievement for young learners* (pp. 182–195). New York: Routledge.

Vandewater, E. A., Rideout, V., Wartella, E. A., Huang, X., Lee, J. H., & Shim, M. (2007). Digital childhood: Electronic media and technology use among infants, toddlers, and preschoolers.*Pediatrics, 119*(5), e1006–e1015.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wang, X. C., Berson, I. R., Jaruszewicz, C. Hartle, L., & Rosen, D. (2010). Young children's technology experiences in multiple contexts: Bronfenbrenner's ecological theory reconsidered. In I. R. Berson & M. J. Berson (Eds.), *High-tech tots: Childhood in a digital world* (pp. 23–48). Charlotte, NC: Information Age.

Wang, X. C., & Ching, C. C. (2003). Social construction of computer experience in a first-grade classroom: Social processes and mediating artifacts. *Early Education and Development, 14*(3), 335–361.

Wartella, E., & Jennings, N. (2000). Children and computers: New technology—Old concerns. *Children and Computer Technology, 10*(2), 31–43.

Wolf, M. (2007). *Proust & the squid: The science and story of the reading brain.* New York: HarperCollins.

World Economic Forum (2010). *The global information technology report 2009–2010,* Retrieved from http://www.networkedreadiness.com/gitr/main/fullreport/index.html.