Chapter 15
Young Children at Risk of Digital Disadvantage

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Abstract It is increasingly apparent that children who engage with digital technologies under certain conditions and in specific ways demonstrate numerous cognitive, emotional, and social advantages. Conversely, children who do not have access to emerging technologies or those who engage with technology in unhealthy ways are digitally disadvantaged. For example, children who play video games for extended periods of time and those who use the internet to isolate rather than network are at risk of social and emotional problems. The Ecological Techno-Subsystem and Techno-Microsystem provide a comprehensive conceptual framework by which to organize and interpret the large body of research on the developmental consequences of technology use during the early years of life. Such a theoretical and evidence-based foundation provides for specific interventions aimed at minimizing early childhood digital disadvantage. For example, public library internet access programs focused on promoting digital information, communication, and recreation literacy may be specifically directed toward young children residing in disadvantaged communities.

Keywords Young children · Risk · Technology · Child development · Digital divide · Digital exclusion · Digital disadvantage

Variation in Early Childhood Digital Experience

Our school has a class set of iPads which are signed out of our library by teachers on a period-by-period basis. I was excited to use the iPads with my first grade students to review and reinforce the mathematical concepts of shape and ordering on the basis of size. In preparation, I had ensured that the iPads had the appropriate icons on the desktop so the children could easily access the applications. "Boys and girls," I started, "I have something special for you, so listen carefully and look at me. These are …" I was interrupted by several children overcome with excitement and delight as they saw the iPads I was about to distribute. A few children began to laugh aloud and vibrate with anticipation. I noticed that some children

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appeared confused as they glanced from the iPads to the other children and then to me. Before I could continue, one child shouted "iPads!" and another implored loudly, "Me please, Miss Smith, me first!" As the iPads were distributed, some children immediately scrolled the screen as they searched for applications while other children appeared increasingly confused and disoriented. As the lesson progressed, most of my time was spent helping children who were unfamiliar with the iPad technology. The children who were the most comfortable with the technology spent the most time identifying shapes and organizing shapes on the basis of size. My lesson included, for some children, digital remediation and, for other children, curriculum acceleration.

Early childhood teachers frequently observe variation in children's background experiences and routinely scaffold instruction to allow all students to move toward mastery of learning objectives. The disparity in out-of-school exposure to digital technologies, however, is particularly evident and immediately consequential in school-based use of new technologies. In teaching her first-grade mathematics lesson, Miss Smith was taken aback by the extreme variation in her students' capacity to interact with iPad applications. Those children who were digitally competent were at a learning advantage; those children who were digitally challenged may have been further disadvantaged by decreased opportunities to engage with enriching mathematics applications. Indeed, based on an increasingly-convincing body of research evidence (Johnson 2012a), the use of digital technology during the early years has a powerful effect on child developmental outcomes. However, because young children in technologically-advanced nations are highly dependent upon adults for access to innovation, children vary widely in their experiences with digital technology, and this is particularly true before mandated school attendance (Johnson 2010a).

This chapter starts with a historical interpretation of adult anxiety regarding young children and technological innovation. Ecological theoretical models of the effect of digital technology use on child development are reviewed and promoted including the Techno-Subsystem and Techno-Microsystem. Recent research findings on the effect of digital technology use on young children's development and learning are synthesized. Based upon that research synthesis, a definition of early childhood digital disadvantage is proposed, that is, digital experiences that are insufficient or inadequate relative to those of developmental peers. From an ecological perspective, digital disadvantage is potentially addressed through support for families, schools, and communities.

Technological Innovation and Young Children: A Historical Analysis

Most typically, fear and suspicion surround the introduction of new technologies, particularly with respect to the young (Johnson 2006); the more vulnerable the youth, the greater parental fear of exposure to the unknown. For example, when

microwave ovens first became popular, there was widespread fear that warming baby food with the new technology would cause cancer. As has been the case with every technological innovation, especially those with which parents and teachers have limited personal experience, there is fear that the innovation will actually cause physical harm (e.g., screen media damages eye sight), expose children to risk (e.g., the internet is a depository of uncensored pornography), and displace healthy activities (e.g., playing videogames reduces outdoor play). In an evolutionary context, such parental fear of exposing children to the unknown has, no doubt, served the species very well.

In the history of technology, innovation is typically first embraced by socially privileged young adults such as male university students of high socioeconomic status (Johnson 2007). Over time, the use of the new technology fans out across the population in predictable patterns. In the case of personal computers with internet connectivity, for example, over the course of two decades, internet use increased both up and down the age range; that is, users became progressively older (Erickson and Johnson 2011) and progressively younger (Johnson 2010a). Simultaneously, as personal computers and internet connectivity became more available and thus more affordable over the course of two decades, progressively more individuals—irrespective of social situation—became digitally connected (Broadband Commission for Digital Development 2012). Indeed, internet connectivity is increasingly perceived as essential for participation in a democracy (Hargittai 2008). The *digital divide*, the first term used to describe social disparity in computer use and internet access (Graham 2011), is unlikely to close because, as new technologies emerge, there are predictable differences in access, especially early access in the processes of popularization of the innovation. This is currently the case with emerging telephone technology where learning and communication advantages are associated with full keypad touchscreen smartphones as opposed to traditional alphanumeric multi-press keypad cell phones (Kent and Johnson 2012).

In an increasingly digitalized society, young children commonly use a range of digital technologies, most notably, television, video games, the internet (Hofferth 2010) and, most recently, cell phones (Divan et al. 2012) and technology-based toys (Gibbons 2012). Based on a large representational sample of American parents of children aged 0–6 years, on a typical day, 2, 13, and 16% for ages 0–2, 3–4, and 5–6, respectively, played video games (an average of 55 min). Approximately 4% of 0 to 2-year-olds, 20% of 3 to 4-year-olds, and 27% of 5 to 6-year-olds used a computer on a typical day (an average of 50 min at the keyboard) (Vandewater et al. 2007). In 2009, 78% of 5 to 7-year-olds in Britain had home access to the internet, and 84% had home access to a video game console (Ofcom 2009). In a sample of Canadian 6 to 8-year-olds, 49% reported using the internet to play games *sometimes* while 32.5% reported using the internet to play games *often* (Johnson 2010a). According to the Australian Bureau of Statistics (2009), 60% of 5 to 8-year-old children use the internet, and 2% use mobile phones. In 2010, the Swedish Ministry of Culture reported that 25% of Swedish children 2–5 years of age use computers several times every week (Lindahl and Folkesson 2012). Roberts and Foehr (2008) observed that digital media consumption spikes during the late preschool period,

decreases during the early school years, and then rises again at approximately 8 years of age. Due to maturational processes, all environmental experiences during infancy and early childhood, including use of digital technologies, are of considerable consequence to child developmental and learning outcomes (Johnson 2010b; Sprenger 2010).

The pediatric recommendation that very young children should not be exposed to screen media and digital technologies may be interpreted in the context of the history of technological innovation. The digital revolution created devices which were quickly adopted by young people (e.g., video games) but with which adults had no experience and thus no understanding. The evolutionary predisposition to protect the young from the unknown may, at least to some extent, be responsible for the common, but frequently unfounded, assumption that digital technology is harmful to young children (Boice and Tarone 2011). Currently, there are two conflicting anxieties surrounding young children and digital technology; first, that the use of such technology may harm children, for example, by exposure to inappropriate content and, second, that children who do not have experiences with these same technologies will be socially and educationally disadvantaged (Johnson 2012a).

For more than 100 years, facilitation of the processes of child learning and development has been guided by theory and research (Keil 2000). In evaluating the developmental consequences of young children engaging with digital devices, ecological systems theory (Bronfenbrenner 1997, 2005) provides a comprehensive conceptual framework by which to organize and interpret relevant empirical evidence and pave the way for the best possible treatment of young children.

The Ecological Techno-Subsystem and Techno-Microsystem

There is a reciprocal and spiraling interaction between child development and elements of the child's environment. For example, as infants develop the ability to manipulate objects in their environment, their manipulation of those objects affects their subsequent development. To illustrate, as an infant shakes a rattle, there is increased understanding of sounds and objects and increased ability to use the muscles in hands and arms. Such increased understanding and ability affect subsequent infant interactions with objects in the environment. All experiences, particularly experiences involving the infant's sensory input and motor movement, influence the course of that infant's development. Not surprisingly, parents and caregivers are eager to provide infants with a range of stimulating and safe environmental experiences including toys and playful adult interactions. As children mature, their capacity to interact with elements in their environment correspondingly increases. Those environmental interactions, in turn, affect patterns of continuous maturation and development. Parents and teachers are eager to provide the maturing child with a range of stimulating and safe environmental experiences including books, games, community exploration, and supervised peer interactions.

Socio-cognitive theorists (Piaget and Inhelder 1973; Vygotsky 1978) propose a reciprocal and spiraling relationship between cognitive capacity and environmental stimulation; that is, cognitive capacity causes the individual to seek out stimulating experiences, which in turn increase cognitive capacity, which causes the individual to seek out more stimulating experiences, and so on. In comparing standardized measures of cognitive ability with patterns of internet use, Johnson (2008) reported that cognitive test scores were consistently greater for frequent users, as opposed to infrequent users, both in general and with respect to specific applications such as online communication. Although correlation does not establish causation, it may be that "cognitive capacity causes the individual to use Internet applications, use of Internet applications causes increased cognitive capacity, which in turn causes the individual to seek out more stimulating Internet applications, and so on" (p. 2103).

Ecological theory provides a comprehensive view of environmental influences on learning and development by situating the child within a system of relationships affected by multiple levels of the surrounding environment (Johnson 2010c). Bronfenbrenner (1977) organized the contexts of development into five nested environmental systems, with bi-directional influences within and among these systems. The *microsystem* refers to direct or immediate interactions (i.e., family, peers, and school). The *mesosystem* is comprised of connections between immediate environments (e.g., home-school interactions). The *exosystem* includes settings that indirectly affect child development (e.g., parent's workplace). The *macrosystem* refers to social ideologies and cultural values that affect the developing child (e.g., child protection services and childcare regulations). The *chronosystem* highlights the effect of time on all systems and all learning and developmental processes (e.g., innovative technologies). As Bronfenbrenner (2005) expanded his theoretical model, he proposed a bio-ecological perspective which viewed the child's biology (e.g., genetic predispositions) as part of the microsystem.

Ecological theory (Bronfenbrenner 1977, 1979) emerged prior to the digital revolution and the developmental impact of then available technology (e.g., analogue television) was conceptually situated in the child's microsystem. To counter this, Johnson and Puplampu (2008) proposed the *ecological techno-subsystem*, a dimension of the microsystem, which includes child interactions with both human (e.g., communicator) and nonhuman (e.g., hardware) elements of digital technologies. Further, they argued that the developmental impact of using digital technologies during childhood is, theoretically, mediated by techno-subsystem interactions which occur in the microsystem (Fig. 15.1). To illustrate, in industrialized nations, elements of children's microsystem (e.g., home and school) are affected by cell phones (e.g., communication with peers). School internet portals are mesosystemic because they connect home and school by allowing parents online access to their children's homework assignments, attendance records, and grades. Parent use of the internet at work, an element of the exosystem (an environment in which the child does not directly participate), may indirectly affect children's home internet access which may ultimately impact on child development and learning (Johnson 2010c). The macrosystem reflects selective cultural endorsement of uses of digital technology (i.e., for school learning and family communication).

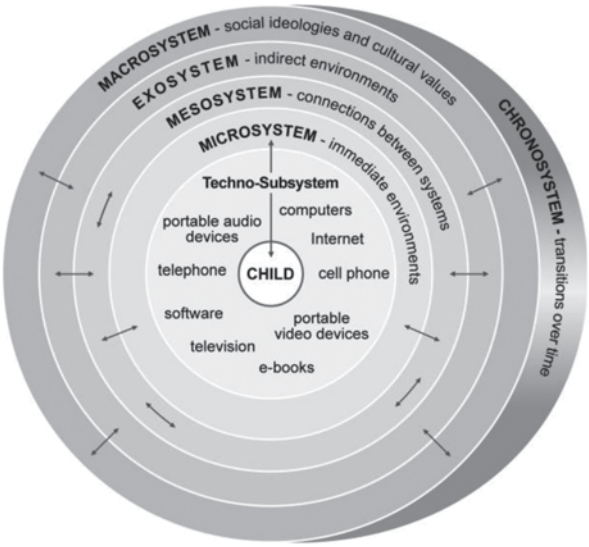

Fig. 15.1 Ecological Techno-Subsystem (Johnson and Puplampu 2008)

While the techno-subsystem highlights the importance of technology in children's learning and development, it fails to provide a precise description of the mechanisms of influence. As presented in Fig. 15.2, the *techno-microsystem* includes the bio-ecology of the child (i.e., cognitive, social, emotional, and physical development) which unfolds in response to various uses of digital technologies across various microsystemic contexts. The microsystem rings surrounding the developing child should be considered as fluid, and the descriptors in the rings are for purposes of illustration. That is, child developmental outcomes are typically conceptualized in terms of domains which include social, emotional, cognitive, and physical. But child development is holistic (e.g., physical development includes brain changes, and brain changes affect and are affected by cognitive development). Further, use of digital technology may also have a range of intentions and outcomes (e.g., iPad applications often provide children with both information and recreation). Nonetheless, the ecological techno-microsystem provides a conceptual framework for organizing dimensions of child learning and development in relation to digital technologies for communication, information, and recreation mediated by home, school, and community opportunities and constraints. "Theoretically, the techno-microsystem has the capacity to, for example, coordinate children's learning experiences across home, school, and childcare environments, protect children from harmful at-home online experiences by community-based web-awareness initiatives, and prioritize school-based hardware for children without home connectivity" (Johnson 2010b, p. 35).

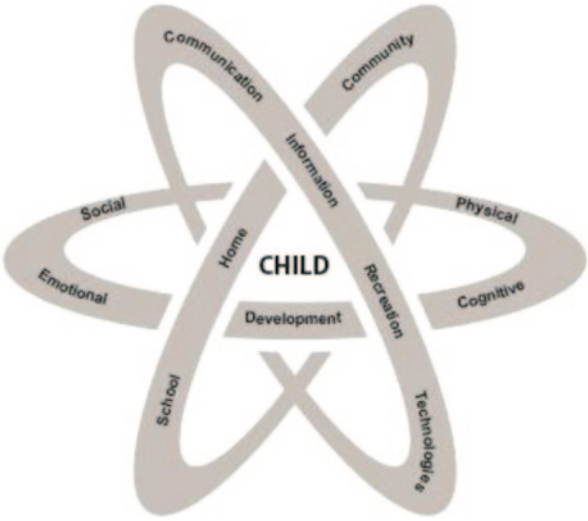

Fig. 15.2 Ecological Techno-Microsystem (Johnson 2010b)

The Effect of Digital Technology on Young Children

The developmental value or liability of any environmental experience may best be determined from an ecological perspective, that is, in the context of the opportunities and constraints that define available environmental experiences from which a child, parent, caregiver, or teacher may select. Obviously, a child should not ingest any substance that may be contaminated unless, of course, there are no other options, as may be the case in situations of starvation and draught. If a mother is experiencing acute gastrointestinal distress, it is better for her young child to view many educational videos and extensively play digital games rather than experience limited environmental stimulation for several days. Scientific research, unfortunately but understandably, provides information on general trends in populations and rarely considers the complexity of individual situations. It is thus that the ecological techno-microsystem may provide a practical focus on the individual child-in-context while simultaneously providing a theoretical structure on which to organize the empirical evidence regarding the effect of digital technology on young children. Indeed, research findings concerning the educational and developmental consequences of using small screen technologies during early childhood are collectively complex and subject to interpretation (Johnson 2009; Livingstone 2009).

One in six Australian children aged 6–7 years has a television in his/her bedroom (Rutherford et al. 2010). Is this good or bad? Based on a comprehensive review of recent research, Mitrofan et al. (2009) concluded that there was insufficient, contradictory, and methodologically-flawed evidence on the association between television viewing and aggression in children. Likewise, television viewing after 3 years of age has not been linked to attention problems (Zimmerman and Christakis 2007). Similarly, Moses (2008) reviewed the research on the effect of television

on young children's literacy and concluded that moderate amounts of television viewing were beneficial for reading. The content of programs viewed by children was important. Programs that aim to promote literacy in young children positively impacted early literacy skills, and there were limitations to the existing literature. Research that takes into account program content generally finds that educational programming is associated with positive academic outcomes while entertainment programs are negatively associated (Brown and Marin 2009). Gentzkow and Shapiro (2008) used heterogeneity in the timing of television's introduction to different local markets to identify the effect of preschool television exposure on standardized test scores during adolescence. Their findings suggested that an additional year of preschool television exposure raised average adolescent test scores by about 0.02 standard deviations. For reading and general knowledge scores, the positive effects were largest for adolescents from households where English was not the primary language, whose mothers had less than a high school education, and for nonwhite children. However, after reviewing 50 years of research, Schmidt and Anderson (2007) noted that a relation between television viewing and reading achievement past the early school years could not be established. From an ecological perspective, research findings support the conclusion that, in environments where young children have many choices of cognitive stimulation, moderate viewing of educational programs facilitates development. In environments where young children have limited choices of cognitive stimulation, extended viewing of educational programs may be necessary to facilitate cognitive development.

Consistent with research on the effect of television on young children, the educational and developmental consequences of playing video games are collectively complex and again subject to multiple interpretations (Steinkuehler 2010). DeBell and Chapman (2006) concluded that computer use promotes cognitive development in children, "specifically in the area of visual intelligence, where certain computer activities—particularly games—may enhance the ability to monitor several visual stimuli at once, to read diagrams, recognize icons, and visualize spatial relationships" (p. 3). In contrast, Johnson (2009) reported that at-home, online learning and communicating (but not playing and browsing) were associated with advanced child development in expressive language and metacognitive planning. Lee et al. (2009) found that, among young school-aged children, time spent reading was negatively related to time spent playing video games. Swing et al. (2010) reported an association between playing video games and increased attention problems during childhood. Focus group interviews with children revealed the perception of overarousal and loss of awareness of surroundings during video game playing (Funk et al. 2006). Anderson et al. (2007) concluded that "no matter how many risk and protective factors the child already has, playing violent video games still adds additional risk for future increased aggressive behaviour" (p. 141). Nonetheless, the learning of 4 to 5-year-olds was reportedly maximized by a combination of traditional teaching methods and interactive video games (Hong et al. 2013). Schotland and Littman (2012) clearly established the learning benefits of video games for teaching complex concepts to 4 to 6-year-olds. From an ecological perspective, research findings support the conclusion that, in environments where young children

have many choices of cognitive stimulation, moderate playing of educational video games facilitates development. In environments where young children have limited choices of cognitive stimulation, extended playing of educational video games may be preferable to other repetitive activities.

Research findings on the relationship between internet and computer use and child learning and development appear to be more uniformly positive than those associated with video gaming. Kumtepe (2006) observed that computer literate kindergarten children were rated by their teachers as demonstrating better social skills than children who were less computer proficient. Cole and Hilliard (2006) reported that reading skills in a sample of third grade students increased more with web-based than with traditional literacy instruction. In comparing traditional and computer-assisted remedial reading interventions, the enduring effectiveness of digital learning tools was apparent (Saine et al. 2010). A meta-analysis undertaken by Cavanaugh et al. (2004) confirmed a positive relationship between internet use during childhood and school achievement. One explanation for this is that the internet, although rich in graphic display, is primarily a text-based medium and therefore "the more a child uses the Internet, the more he/she reads" (Jackson et al. 2007, p. 188). Fiorini (2010) concluded positive and enduring cognitive benefits of computer use during early childhood with evidence of associations with proactive social behavior. In a comprehensive review of the literature, McCarrik and Li (2007) concluded that young children who used computers, compared to those who did not, demonstrated significant and global developmental superiority. From an ecological perspective, internet and computer use facilitate a range of positive developmental outcomes during early childhood, although physical and social interaction must not be limited. As previously argued, "Current anxiety surrounding children's Internet use should be for those whose cognitive processes are not influenced by the cultural tool" (Johnson 2006, p. 570).

Unlike technologies such as the internet, television, and video games, cell telephones are a relatively recent childhood phenomenon, and research is just emerging. Given historical patterns of digital technology penetration, younger children might reasonably be expected to increasingly use cell phones. Bond (2010) indicated a possible explanation for this. Cell phones are viewed by children as essential to supporting relationships and offering security and reassurance. Mezei et al. (2007) reported a strong relationship between cell phone ownership during childhood and duration of time spent watching television and playing computer games, although no relationships to attention or obesity emerged. According to Cameron and Hutchison (2009), young children's telephone-mediated language can, under certain circumstances, be more generative, explicit, and elaborative than previously believed. From an educational perspective, using cell phones to learn is expected to increase among all age groups (Kim et al. 2008). Smart phones may be particularly beneficial as they have applications for young children which support the development of emergent literacy (Blanchard and Moore 2010). Young children's increasing engagement with cell telephones, text messaging, and similar communications technologies might well be harnessed for pedagogical purposes in emergent literacy (Gillen et al. 2005). "In contrast to teacher reports, recent research suggests that use

of textese (i.e., idiosyncratic written conventions used in text messaging) is positively associated with Standard English literacy skills during childhood" (Johnson 2012b, p. 1). From an ecological perspective, cell phone use during the early years has the potential to facilitate child development if used to increase communicative opportunities.

Digital technology has had a strong influence on children's toys and the nature of play (Spatariu et al. 2012). "In today's digitally-intense world, young children represent a key target demographic for digital consumer electronic devices" (Gibbons 2012, p. 4). There are now laptop computers for infants and toddlers, electronic talking books, animated stuffed animals and dolls, digital cameras for very small hands, and battery-driven toys including infant rattles and crib mobiles (Wooldridge and Shapka 2012). The toys listed on the Parent's Choice Awards (2009) included toys with electronic and computer components including a night-vision camcorder, a laptop device that teaches spelling and counting, remote control devices, board games with electronic features, and a robotic insect. The buzzword at the 2012 Toy Fair was *augmented reality*. Many of the exhibitors introduced toy cars, puzzles, board games, and other playthings that work with iPads or other handheld devices. The idea is that, rather than replace the physical toy, digital applications enhance play and increase toy sales. Several toy companies have launched entire product lines based on this concept, including Mattel's Apptivity, Spin-Master's Appfinity, Hasbro's zAPPed, and WowWee's AppGear brands, while others launched one or more individual augmented-reality items (Raugust 2012). Because popular use of such toys is relatively recent, the effect of their use on child development and learning has yet to be systematically investigated. It seems likely, however, that use of such toys will soon be linked to positive developmental outcomes for children, perhaps because only children who are socially advantaged have opportunities to engage with new high-tech toys. From an ecological perspective, because technical competence is culturally-valued and because technology-enhanced play experiences often stimulate problem-solving, memory, and communication, electronic toys likely facilitate child development and learning particularly in the context of a wide range of varied environmental opportunities. Young children without a wide variety of culturally-valued and stimulating environmental experiences are unlikely to develop to their maximum genetic potential (i.e., bio-ecology). With respect to technologically-advanced societies, while it is possible that a young child without digital experiences might develop normally, in general, it seems quite unlikely.

Young Children at Digital Disadvantage

Consider a 5-year-old starting kindergarten having never watched television, never talked on a telephone, and never listened to recorded nursery rhymes. Such restricted experiences would make it difficult for the child to feel comfortable in the increasingly digitalized early childhood education classroom (Gibbons 2012).

Equally, such a child may have difficulty interacting effectively with other children whose conversation includes television characters and electronic toys. However, 50 years ago, few children viewed television, talked on telephones, and listened to recorded nursery rhymes. In understanding child development, there are few absolutes because developmental expectations reflect culture, and cultural nuances change over time (i.e., the ecological chronosystem) particularly in technologically-advanced societies. From an ecological perspective, developmentally-ideal environmental experiences can only be conceptualized in the context of available opportunities which differ widely across children. If all children enjoyed an equal variety of culturally-endorsed environmental opportunities, the author's recommendation would be that all children experience, for example, during the first year of life, auditory stimulation in the form of consistent communicative partners who provide ample age-appropriate language including singing, rhymes, naming, explanation of relationships between objects, and pairing vocabulary with visual and tactical experiences. Since all children do not have access to such a communicative ideal, digital recordings may provide some level of audiological stimulation in some situations. During the seventh year of life, to continue the example, a child would benefit from familiar and trusted communicative partners and communicative modes including text-based (e.g., email to grandparents), video-based (e.g., Skype with relocated playmates), and digitally-mediated (e.g., cell phone calls to working parents). Such digital experiences, in the context of a variety of physical activities and face-to-face human interaction, may be considered ideal.

But extreme digitalization of experience, particularly of certain types, according to the research evidence, is not in the best interest of young children, except perhaps in the most extreme and unusual circumstances where environmental opportunities are severely restricted. During the early years, exposure to and use of digital technologies may best be conceptualized as environmental experiences that reside within a context of a wide range of culturally-valued and age-appropriate experiences that simultaneously maximize child physical, cognitive, social, and emotional developmental potential (i.e., bio-ecology). To illustrate, a child may feel emotionally comforted by cell phone contact with parents (Bond 2010), but such contact should augment, not replace, direct and intense personal contact with parents. Most young children would benefit from playing educational video games (Schotland and Littman 2012), but no young child should be exposed to prolonged use of violent video games (Anderson et al. 2007; Funk et al. 2006). A young child with high needs for cognitive stimulation would benefit from digital multitasking during quiet time (e.g., listening to a talking book while practicing concepts with an iPad application). Thus, digital disadvantage during the early years is not a binary state but, rather, a matter of degree. In technologically advanced nations, digital disadvantage is manifest by the degree to which young children lack digital experiences that are culturally-valued, age-appropriate, and normative. Digital disadvantage may include, for example, isolated and excessive television viewing and video gaming which will not, generally, maximize child developmental outcomes.

Addressing Digital Disadvantage: The Role of the Family

Young children, most typically, reside in families, and the characteristics of those families, from an ecological theoretical perspective, determine the degree of digital advantage or disadvantage. Within the context of the family, two issues particularly influence the quality and quantity of young children's digital experiences: physical access and patterns of *co-use* (a term preferred over terms such as monitoring or supervision). As evidenced by the mounting literature on the digital divide, not all children have home access to digital communication and information technologies (Livingstone and Helpsper 2007). Family socioeconomic status, including parent education and family income, is at the heart of the digital divide (Krebeck 2010), and such family characteristics are linked to patterns of young children's use of technology. Indeed, numerous researchers have concluded that differences in access to emerging technologies tend to reinforce and replicate existing social inequalities (Dutton and Helsper 2007; Eynon 2009). In a comprehensive cross-sectional and longitudinal analysis of technology use among children 5–8 years of age, Lee et al. (2009) reported that family income significantly predicted children's use of new technologies such as personal computers. Correspondingly, higher parental education has frequently been associated with decreased television viewing by children (Australian Communications and Media Authority 2009; Baxter and Hayes 2007). Thus, perhaps not surprisingly, young children who are socially advantaged in terms of family characteristics are also digitally advantaged by virtue of the same family characteristics. Technology co-use, however, adds another dimension to the digital advantage—disadvantage continuum.

Co-use is a general term used to refer to the social sharing or cooperative use of digital technologies (Johnson 2012a). With respect to young children and digital technology, co-use with a more mature partner facilitates the development of digital competencies while simultaneously protecting the child from digital risk (e.g., inappropriate content and excessive use). Cho and Cheon (2005) surveyed families and found that parents' perceived control, obtained through shared web activities and family cohesion, reduced children's exposure to negative internet content. Lee and Chae (2007) reported a positive relationship between parental mediation techniques (i.e., website recommendation and internet co-use) and children's educational attainment. Yoon (2003) observed that cell phone use extended parental control because contact and monitoring of children was always available. From a developmental perspective, young children's digital experiences are always improved when shared with a partner who explains, extends, questions, confirms, monitors, and adjusts to maximize the cognitive, social, and emotional benefits of the digital interactions. This is equally true of television viewing and video gaming. The role of the family is unchanged following the digital revolution. That is, families remain directly responsible for maximizing the developmental outcomes of children during the early years. Parents make choices on behalf of young children and those choices, if possible, should provide children with a wide range of culturally-valued and age-appropriate experiences. In this regard, excessive use of digital devices

should be avoided. Varied environment experiences will include, as the child grows, increased use and co-use of digital technologies that facilitate concept development, social interaction, and emotional security. As families consider childcare options, the digital opportunities available to young children should be considered.

Addressing Digital Disadvantage: The Role of the Childcare Provider

Many parents of young children rely on various forms of non-family childcare in order to engage in paid employment, run a business, increase educational attainment, or because it is deemed in the best interest of the child (Ansari and Winsler 2013). Research has clearly established that high quality child care does not harm children and, in fact, often complements parenting to maximize child developmental outcomes (Bekkhus et al. 2011; Gimenez-Nadal and Molina 2013). While high-quality care is typically described in terms of staff-child ratios and child health and safety, recent focus group interviews conducted with low-income parents of children aged 2–5 years in Baltimore revealed parents' desire that their young children experience digital technologies while in care settings (Forry et al. 2012). Apparently, parents understand the importance of young children developing information and communication technology (ICT) literacy. According to Morrison (2008), when child care professionals support children's use of computer technology in their centers, it helps children to develop skills such as the use of a keyboard and basic computer software. "It also assists children to build learning concepts around computer use and digital media over time. This will ultimately help children to function in learning environments where skills involving computer use are beneficial and/or necessary" (p. 15). *Computer Gym* is an online site that provides weekly computer-based lessons to pre-school children at childcare centers. Initial lessons of the program "focus on early computer skills such as mouse control and movement, confidence and social skills on the computer. All children will also do activities with an emphasis on self and relationships as well as early literacy and numeracy topics" (Computer Gym 2013, p. 1).

Despite parental desire and increasingly-available opportunities, many child care centers remain reluctant to include digital devices in young children's play and learning. This may be a manifestation of continued fear of exposing the young to the unknown, a common pattern in the history of technological innovation, as previously discussed. It may also reflect misunderstanding of the nature of recent digital innovation. The American Academy of Pediatrics recommends limiting screen time to 1–2 h of quality programming per day for preschool-age children (Tandon et al. 2011). Such a recommendation, however, refers most obviously to television. Many current uses of digital technology, although they include a small screen, are highly interactive. For example, the internet is not like other media in as much as it is used primarily for communicating, information gathering, and playing games rather than for passively experiencing narratives (Johnson 2009). iPads are promoted as

extremely useful for young children (Dixon 2011) because tablets' mobile capability, touch screen, and intuitive operation make the devices appealing to many, and are especially valuable to children with special needs (Johnson 2013). From an ecological perspective, there are few absolutes in terms of maximizing child developmental outcomes. There are numerous situations in which young children may benefit from playing with iPad applications in childcare centers, particularly if the center is their only opportunity to gain familiarity with small screen interactive applications. The child care provider may function as a mechanism of increased social equity as long argued by the proponents of early intervention programs for young children at risk (Lipscomb et al. 2013). Since all children in industrialized nations attend school at a relatively young age, 4–5 years, the school has the capacity to reduce digital disadvantage.

Addressing Digital Disadvantage: The Role of the School

According to Spatariu et al. (2012), "each generation of children come to early childhood programs with increasingly different experiences and exposure to technology" (p. 24). Arguing the importance of ICT in early childhood education, a recent report by UNESCO claimed that "research done on the learning of North American and European children has discovered that as much as 80 percent of knowledge they gain by the age of 11 is learned from the non-print media outside the classroom" (Kalaš 2010, p. 7), although methodological details were not provided. In addition to the critical role of technology in informal knowledge acquisition, young children are highly motivated to interact with digital devices. For example, Course and Chen (2010) reported that preschool children, 3–6 years of age, preferred drawing on tablet computers rather than using paper and pencil. In many studies of preschool children, learning with computers was associated with better achievement in literacy, mathematics, and science compared to traditional learning activities (Vernadakis et al. 2005). Unfortunately, there is often considerable disparity between the technological skills of early childhood educators and the digital learning needs of their young students (Lindahl and Folkesson 2012). Fortunately, curriculum standards in advanced nations mandate digital competencies during the early school years. For example, 5-year-old children in Australia are expected to "construct texts using software including word processing programs" and "understand concepts about print and screen, including how books, film and simple digital texts work, and know some features of print, for example directionality" (Australian Curriculum, Assessment and Reporting Authority 2013, para. 1). Thus, school-based use of digital technology during the early years facilitates mastery of curriculum concepts as well as increases culturally-valued digital literacy.

Addressing digital disadvantage in the early childhood classroom requires technologically-competent early childhood educators who have access to required software and digital devices. Increasingly, early childhood teacher preparation programs include courses directed toward interpreting curriculum in the digital context

(Thomas and Spencer Cooter 2012). Teachers of young children must integrate digital experiences into the school day in a variety of ways, including: ICT and the outdoor environment, using computers and software, ICT and creativity, using a smart board, and using digital cameras and scanners (E2BN 2008). Digital experiences are easily integrated into a play-based curriculum that supports key areas of learning such as collaboration, communication, exploration, and socio-dramatic play (Siraj-Blatchford and Siraj-Blatchford 2006). In personalizing learning experiences, children who are digitally literate may benefit from non-digital experiences including physical building blocks and traditional early childhood musical instruments. Children who are digitally illiterate may require extensive exposure to, for example, iPad applications and internet websites, although a range of sensory, motoric, social, and cognitive experiences during the school day are ideal for all young children. According to Zevenbergen and Logan (2008), computer access in early childhood settings should be improved in order to reduce digital divides among early childhood learners. Early childhood teachers may provide parents with information on age-appropriate use of digital devices and emphasize the importance of presenting young children with a range of experiences and opportunities. Out-of-school parental reinforcement of young children's school-based skills and concepts should include, as may be appropriate, parent-child co-access of teacher-recommended websites and co-use of recommended software and applications. In some cases, parents may be able to borrow digital devices from schools; but among the most digitally and socially disadvantaged, the provision of devices becomes a community responsibility.

Addressing Digital Disadvantage: The Role of the Community

Ideally, young children should enjoy a variety of environmental opportunities that include home- and school-based experiences with small screen digital devices that facilitate concept formation, social interaction, and emotional security, among other positive developmental outcomes. When home access and age-appropriate use are lacking, the early childhood classroom provides digital learning opportunities and the early childhood teacher provides digital guidance and direction to parents of young children. There are many situations, however, when family circumstances require more than the early childhood classroom teacher can reasonably provide. In such situations, a community-based effort is required which may include, for example, programs that provide access to digital devices and internet connectivity.

In technologically-advanced societies, the provision of internet access is increasingly viewed as central to the mission of the public library (Kinney 2010). In a 2002 survey of Australian public libraries, approximately one-third reported providing internet training specially targeting children. Forty-seven percent provided websites for children that linked to recommended material, 16 % provided separate terminals for children, 72 % required parental consent for children to use the internet, and 26 % required a parent to be with children using the internet (Australian Library and

Information Association 2010). In 2012, a public library in Wisconsin was among the first to lend iPads in large numbers. "Demand for the iPads was high for quite some time after their introduction, and at one point the number of holds remained around 400" (Price 2012, para. 4). A Connecticut public library recently introduced an eTot program for 2 and 3-year-old children and their caregivers. The head children's librarian explains, "As I hand out the iPads, we recite an iPad poem based on the nursery rhyme 'One, Two Buckle My Shoe.' As we read the book app together, I alert everyone to any interactivity on the screen, to make sure no one misses these features. When the reading is finished, we open another app—generally an educational or entertaining title, and I offer the adults a few pointers on using it. After that everyone is free to explore whatever they like" (Wall 2013, para. 7). While such initiatives are currently enjoyed by socially-advantaged children, specifically targeting the digitally disadvantaged should constitute a priority and may require library out-reach programs.

In organizing the impact of environmental experiences on the developing child, the Ecological Techno-Subsystem (Johnson and Puplampu 2008) is surrounded by nested systems, including the macrosystem, which includes social ideologies and cultural values. It could be argued that the provision of connectivity is as much a public responsibility as is the provision of a safe supply of drinking water. Internet connectivity and devices such as iPads with children's ebooks (Chiong et al. 2012) and educational applications can hardly be considered frivolous in the current highly-digital and seemingly democratic context. Community-based programs that specifically target young children at digital disadvantage might include home visits from volunteers who update software applications and provide role models of digital literacy for both young children and their parents.

Summary and Conclusion

There is a reciprocal and spiraling interaction between child development and elements of the child's environment. The Ecological Techno-Microsystem (Johnson 2010b) emphasizes the importance of direct digital experience in children's development because such experience is normative and because such experience, under some conditions, facilitates positive social (e.g., communication), emotional (e.g. security), and cognitive (e.g., problem solving) developmental outcomes. From a developmental perspective, young children at digital risk are those whose digital experiences are insufficient or inadequate relative to other children of the approximate developmental status (i.e., peers). Once children start school, reducing digital disadvantage becomes possible, but many schools lack the resources necessary to ensure digitally-enriching experiences for all children, particularly those who do not enjoy such experiences at home. The provision of class sets of emerging digital devices and the digital up-skilling of early childhood teachers would function to provide all children with digital advantages.

Johnson (2010c) examined the relationships between family socioeconomic status and children's internet use and cognitive development. Reportedly, family socioeconomic status accounted for 5–7% of differences in child cognitive-developmental test scores. In contrast, indices of home internet use during childhood accounted for up to 29% of differences in child cognitive-developmental test scores. Structures of social equalization (e.g., public education, quality child care, preschool interventions, and prenatal programs) have not proven entirely effective in erasing differences in the quality of children's environments, particularly home and community environments. While family access to food and housing may have improved in recent decades, access to technological innovation is restricted to families with considerable disposable income. As society moves forward, technological progress is not uniformly experienced. But if any group must not be left behind, it is the youngest, the most vulnerable and, without question, the most important to the future of that society.

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