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Looking beyond swiping and tapping: Review of design and methodologies for researching young children's use of digital technologies

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Abstract

We conducted a systematic, in-depth literature review to examine the research around digital technology and media technologies for young children. We were particularly interested in understanding the range of research designs and specifics about elements of the method employed for researching digital technologies with young children (i.e., birth to 5 years). We focused precisely on this age group because it overlaps with the early childhood education period, and recent policy statements that focus on technology usage in young children and offer varying recommendations for children whose chronological age falls in the first five years of life. We completed a detailed analysis of 60 studies published 2011 to 2015; our synthesis focused on describing the research designs, and several specifics of the research method in each primary source: child demographics, the materials used in the research tasks, and the social and cognitive nature of tasks that children engaged in throughout each empirical study. Our findings provide insight for a framework that captures the complex interplay between child development, learning, lived experiences, and social contexts that surround the use of digital technologies.

Keywords: Children; design; digital technology; research methodology; interactive media

Introduction

Considerable attention is being directed towards the role that technology and interactive media play in children's lives. Much of this attention can be attributed to the significant increase in the access to, and use of, mobile electronic devices. In the United States, the percentage of families with children reporting access to mobile devices, including smartphones and tablets is continually growing. For example, this percentage rose from just over half (52%) in 2011 to three-quarters (75%) in 2013 to nearly all (98%) children in 2017 (Rideout, 2017). A similar trend has also emerged for usage: in 2011, 38% of children had used some type of mobile device, and by 2013, this percentage had risen sharply to 72%, and by 2017, usage increased to 84% (Rideout, 2017). Parallel trends have been observed in early childcare and education settings, (e.g., Blackwell, Wartella, Lauricella, & Robb, 2015), especially in urban, low-income, and minority communities in both the United States (e.g., Kabali et al., 2015) and United Kingdom (e.g., Marsh et al., 2015; OfCom, 2014). In Australia, 97% of households with children reported access to the Internet with most using desktop or laptop computers (94%), mobile phones (86%), and tablets (62%; Australian Bureau of Statistics, 2016). Together, these reports demonstrate

unequivocally that, within the developed world, there have been a rapid and significant increases in the access to, and use of, mobile devices for children under the age of 6.

In response to these increases, organizations, like the American Academy of Pediatrics (AAP), have revised previous policy statements to include specific recommendations for health care providers, parents, and educators of children from birth through age 8 (AAP, 2016). The majority of these recommendations focus either on minimizing risk through restrictive mediation (e.g., screen time limits) or maximizing opportunity through more active mediation (e.g., co-viewing media with children) (Blum-Ross & Livingstone, 2017). The inclusion of active mediation strategies pivots away from original recommendations, which imposed a two-hour daily maximum on exposure to screens for children over the age of two (AAP, 1999). Currently, the AAP (2016) suggests that adults co-engage with children during screen time in order to provide support for the technologies being used, as well as conversation about the media being consumed. Similar guidelines for parents and early childhood professionals on early learning and technology have been released by National Association for the Education of Young Children (NAEYC) in conjunction with the Fred Rogers Center (2012) and the U.S. Departments of Education and Health and Human Services' (2016).

While the recommendations listed above have come from American organizations, parallel initiatives are occurring internationally. For example, the UK Council for Child Internet Safety developed guides for parents, similar to those developed in the United States, which focus on understanding and mediating the possible risks associated with screen time (see Livingstone, Davidson, Bryce, Hargrave, & Grove-Hills, 2012). The National Health Service (2013) has taken a more conservative approach, suggesting more restrictive mediation, based on evidence linking screen time to poorer health outcomes. In Australia, screen time guidelines developed by the Australian Department of Health (2012) recommend children younger than two years of age not watch television or use any other electronic media. For children aged two to five years, the guidelines recommend one hour of screen time per day and for parents to engage in active creative play with their children without the use of electronic media.

In spite of these proposed restrictions on technology use and media consumption, there has been a movement within the early childhood space to incorporate digital technology in play-based experiences that occur in homes and in early childhood classrooms. This movement is due, in part, to research demonstrating the utility of digital play and its potential role as a positive contributor to early learning. For example, the Australian national early childhood curriculum framework, the *Early Years Learning Framework* (2009), promotes digital play within the early childhood curriculum for preschool-aged children. Similarly, the Australian Children's Education and Care Quality Authority (2015) provide supportive guidelines on using digital touch technologies with young children to promote learning.

In light of these recommendations that have a very real impact on children's development and learning, it is crucial to examine how the research, including the design and methodologies being used, that might influence policies that have evolved and will continue to evolve. The innovation around digital technology is simply outpacing the best efforts of the research community. That is, the research community is challenged with newer forms of technologies in which current research methods may not be appropriate or may need to be developed in order to adequately examine its effects. This is especially true for research initiatives aimed at investigating the impact of digital technology on specific populations; particularly, young children under the age of five years.

In this paper, we provide an overview of the research design and methodologies used to study young children's use of digital technology[1] since the release of tablets in 2010. We also acknowledge other reviews conducted during this time period and within the early childhood technology and media space—specifically, theoretical reviews (e.g., Ko & Chou, 2014; Neumann & Neumann, 2014), prospective and retrospective reviews (e.g., Alper, 2014; Fuller, Lizárraga, & Gray, 2015; McPake, Plowman, & Stephen, 2013; Ólafsson, Livingstone, & Haddon, 2013; Sherry, 2013; Staiano & Calvert, 2011), and meta-analytic work (e.g., Nikkelen, Valkenberg, Huizinga, & Bushman, 2014)—while noting that a very limited number of these reviews, however, detail specific methodologies for their review process, or apply precisely to the 0-5 year age range, which is the focus of the present study. Given these constraints, our focus is on children from birth to 5 years of age, as this specific subpopulation captures the earliest entry point for young children in terms of interacting and engaging with digital technologies.

The present study addresses the following questions: (1) What are the demographics of participants in studies of early childhood and digital technologies? (2) What are the research designs used for these studies? (3) What types of devices are used in early childhood studies and what kinds of tasks are children completing? (4) What is the social context surrounding these studies? These research questions drive the focus of our review and synthesis around the research design and methodologies of digital technologies and media in young children. Our goal is to understand the scope of research designs employed and the ways in which the methodologies being used in the study of young children's use of and interactions with digital technologies are distributed in the existing empirical research base.

Methods

A systematic review was conducted using similar procedures that were used in the creation of the National Early Literacy Panel report (2008) and the National Reading Panel report (2000) and also the approach to research synthesis as described by Cooper & Hedges (1994). We use a sample of the literature from Paciga and Donohue's (2017) integrative research report that focused on children from birth through 8 years of age; our review is specifically on children from birth to 5 years of age. A detailed explanation outlining the inclusion criteria, search strategy and data sources as well as the data coding and analysis are provided below.

Data Sources and Search Strategy

A comprehensive search strategy for this literature review combined snowball sampling and systematic database searches with reverse and hand searches. The databases (EBSCO, ERIC, ProQuest, Medline) were searched from August 1, 2015 through March 2, 2016 and were limited to peer-reviewed, English-language articles. The results of the search were downloaded to Zotero citation software (https://www.zotero.org) and duplicates were removed by hand. Google searches and snowball samples were also conducted to include white papers from other research institutions (e.g., the U.S. Department of Education also focuses on the domain of early childhood and technology/digital media).

The search strategy for locating peer-reviewed articles related to three broad areas: (1) early childhood education, (2) technology and media, and (3) social and emotional constructs. Within these broader areas, search terms related specifically to age and technology/media. Age-related terms focused exclusively on children from birth through 8 years of age: early childhood education, early experience, infant, toddlers, preschool, kindergarten, first grade, second grade, third grade, and young children. Another set of search terms related exclusively to technology (i.e., devices) and media (i.e., interactive) were applied to pool a second set of studies: computer, laptop, tablets, interactive whiteboards, mobile, smartphones, cameras, audio recorders, Nintendo, Xbox, PlayStation, e-book, Kindle, Nook, apps, software, media and Internet. The Boolean "AND" was utilized to identify the literature in common between the two sets. In addition to set search strategies, hand searches were also conducted for the following journals from 2011 to 2015. Articles that were published online ahead of the print version were also included in the search process (i.e., online first and print version later). The journals that we searched by hand included: *Young Children, Teaching Young Children, Teaching Exceptional Children, Child Development, Early Childhood Education Journal, Journal of Early Childhood Literacy,* and *Journal of Children and Media.*

A total of 595 entries were identified that met the criteria for age and inclusion of technology and media (Paciga & Donohue, 2017). From these 595 entries, a stratified random sample for each publication year in the database was created using a random number generator; 165 entries warranted further evaluation. For the reasons detailed in the introduction and statement of goals for this paper, we focus solely on those of 165 entries, described above, that met the following criteria: a) rigorous methodological design, b) a focus on children birth to age five, and c) publication within the last five years, in this case between 2011 and 2016. Sixty such empirical studies[2] were identified for the analysis. Table 1 provides an annual snapshot of the earmarked studies in each of the three contexts described above: a) the entire database, b) the original Paciga and Donohue study (2017), and c) the present study.

Table 1. *Annual Comparison of Entries in Database to Sample Entries.*

	2011	2012	2013	2014	2015	2016	2017
Database (*n* = 595)	44	73	109	140	181	47	1*
Sample used in Paciga & Donohue (2017) (*n* = 165)	14	22	36	36	43	13	1*
Sample used for the present study (*n* = 60)	3	5	13	11	20	7	1*

Note: *Danby, et al. (2017) was received September 2015 and was coded originally as 2015. Publication date was updated to reflect most accurate citation information after the coding and analysis were complete.

Data Coding and Analysis

Once the literature was identified and a sample was set, we coded every entry for certain kinds of data to answer our research questions. Initially, we used an open coding process to identify themes related to the context, child and content. Once we examined 5% of our sample, we examined themes and major patterns to generate variables and within variables, the appropriate levels to use for coding. There were times when the small sample did not represent a certain level within a variable and for those cases, we created additional variables or added additional levels. In those cases, we double-checked the previously coded entries to ensure that adding additional variables or levels within variables did not change previously coded entries. A codebook was developed to differentiate five domains of key variables: 1) entry information generated; 2) demographics and characteristics of the children and adults described; 3) technologies and media used in early childhood education contexts; 4) the types of contexts and interactions in which the participants were using technology and media; and 5) the extent to which interactions provided support for children's social and emotional development and/or learning readiness.

Demographics. Children's age ranges were coded in chronological age according to the following cut off points: infant (0-18 months), toddler (18-36 months), and preschool (3-5 years). Each age range category (e.g., infant, toddler, preschool) was coded binary with a "1" indicating that a child of that age range did participate and/or was described as part of the study and a "0" indicating that a child of that age range did not participate nor was described as part of the study. The age range was not mutually exclusive; studies could have both infants and toddlers participate and as a result, both of these would be coded as a "1" to indicate that both infants and toddlers did participate in the study.

We also documented the socioeconomic status (SES) of participants in the study. Each study was coded with a "1 – identified low SES" if the study identified at least 1 or more child(ren) from a low SES background, a "0 – not low SES" if the children came from only middle or high SES backgrounds or a "99 – did not report" if the SES background was not clearly described or identified.

We also documented the presence or absence of children that were from linguistically diverse backgrounds. For example, children that were described as bilingual or English Language Learners were identified and coded as a "1 – linguistically diverse", "0 – English only", or "99 – did not report".

Finally, we documented children with exceptional needs and rights. For example, children with a 504 plan or Individualized Educational Plan (IEP – example from United States) were identified and coded as "1 – exceptional needs and rights identified", "0 – no exceptional needs and rights identified" or "99 – did not report".

Research design. We evaluated the design of each entry based on major designs for research methods described in Green, Camilli, and Elmore (2006), utilizing the same codes employed by other early childhood professionals currently engaged in research synthesis (i.e., Hoffman, Whittingham, & Teale, in review; Teale, Whittingham, & Hoffman, 2016) which include: comparative, intervention, literature reviews, correlations, descriptive, formative, policy, measurement validation, meta-analysis, and an 'other' category to account for those pieces that deviate from these categories.

We also documented the types of research instruments used to gather evidence for these empirical studies, including instances where multiple or mixed methods were designated. The following methods were identified: survey instruments (including phone, online, and mailed formats); direct observation of children using technology or media, field notes, video- or audio-recorded interactions, and/or observational rating scales; child or parent interview or focus groups; and content analyses of digital media to examine the ways in which the design of the media could interface with the child's experience during interactions.

Screen time. We coded the amount of time children spent with technology or media in the study. We used the following six categories: unable to determine, less than 5 minutes, 5-10 minutes, 11-20 minutes, 21-45 minutes, and 46+ minutes. We recorded the amount of screen time only when the entry specified the event for a child or for children for a specific age range. In addition, the number of minutes had to be presented or easy to calculate. For example, Simcock, Garrity, and Barr (2011, p. 1610) stated "The media demonstration was repeated twice in succession, which took approximately 1 min for both the video and book". This particular example was coded as less than 5 minutes since each child experienced a total of 2 minutes with technology and media. Some of the studies were 'unable to code' for the following reasons: 1) there was no single event described from which they were able to identify a time for a child's interaction with technology or media (e.g., Cohen, Hadley, & Frank, 2011; Flewitt, Kucirkova, & Messer, 2014); 2) there were children of multiple age groups described in aggregate—children were studied in more than one age group, but we were not able to disaggregate the information on time by the child's age from the primary source (e.g., item 17 "Thinking just about YESTERDAY, about how much TIME, if any, did [CHILD'S NAME] spend" in Common Sense Media, 2013; item A-Q3a "On a normal weekday, how much time does your child spend using the devices they have access to" in Marsh et al., 2015).

Task environment. We coded for technology and specifically, the device type used. We coded for the following devices: TV/DVD player, iPod, tablet, computer with mouse, laptop computer, interactive whiteboard, gaming console, digital camera (stand-alone), cellular/smart phone, robot (screen free), multiple device types, and device type not specified. We also coded the use of media as either literacy, math, science, and language.

We also examined the physical spaces, or contexts for the children's use of technology. Researchers typically identified only one mutually exclusive place and as a result, we used the following codes for context: home, family child care, laboratory, early child care center, Head Start center, public school, private school, library, multiple contexts, or not identified. We utilized the not identified code in instances in which the physical place of the entry was not mentioned specifically. The institutionalized child care and school contexts (early child care center, Head Start center, public school, private school) were eventually collapsed and recoded into one variable level, named child care center or school. We also created second variable to indicate whether one or more (US) Head Start or early childhood care center was described in the entry. This allowed us to draw conclusions about the extent to which research relates to these particular contexts, which are often governed by laws and rules different from those governing school contexts, for young children's interactions with technology and media.

Social environment. A child's interactions with technology and media often involve other the people in the child's social world (peers, siblings, parents, caregivers, teachers, etc.) (Marsh et al., 2015). At times, there are several adults collaborating with or through technologies or media about the child or the child's work. We coded for teachers/child care providers, parents/caregivers, interventionists/therapists, other adults, or no adult. When no adult was described as involved in any of the child's interactions with technology or media in the entry, we entered zero values in all of the adult variable fields.

Our "support" variable allowed us to evaluate whether other adults provided active scaffolding or mediation for the child's experiences. We coded support in four mutually exclusive levels – unclear/ not described (i.e., not providing sufficient elaboration regarding a child's encounter with technology or media to draw conclusion), none, some (e.g., adult oriented the child to the objectives/purposes of the activity only), and significant (e.g., adult provided ongoing support and scaffolding/feedback for the majority of the child's interactions utilizing technology or media).

The "grouping" variable allowed us to examine whether a child was engaged in joint use (adult-children, adult-child, or child-child) typically found in a co-viewing scenario, individual use, or multiple grouping methods, that would be typically present in a gradual release of responsibility model of instruction.

Results

Demographics

An overwhelming majority of these studies involved children between 3-5 years of age (83.3%), while far fewer involved toddlers (18-36 months; 41.7%). Within this sample, infants (birth to 18-months) were the least studied sub-population (26.7%). Moreover, 31.7% of these studies involved children living in homes and communities identified as low socio-economic status (SES) and 11.7% identified one or more children with exceptional needs and rights (e.g., individuals diagnosed with autism). Lastly, 15% of these studies identified participants as English-language learners.

Research Design

The majority of these studies used comparative methodologies (*n* = 20, 33.3%), whereby researchers compared two or more groups or individuals on a common process or outcome, or compared outcomes of similar groups with varying experiences as a function of the media (Green et al., 2006). The second most common design of these studies was descriptive (*n* = 19, 31.7%), presenting detailed accounts of the ways in which individual children, as well as groups of children, utilized technology. Other research designs each contributed less than 9% to the overall sample including literature reviews (*n* = 5, 8.3%), intervention (*n* = 4, 6.7%), correlational (*n* = 4, 6.7%), formative/design-based research (*n* = 4, 6.7%), other (*n* = 2, 3.3%), measurement validation (*n* = 1, 1.7%), and meta-analysis (*n* = 1, 1.7%; see Table 2).

Table 2. *Entry Types.*

	Number of Entries	Percent of Entries
Comparative	20	33.3
Intervention	4	6.7
Literature Reviews	5	8.3
Correlational	4	6.7
Descriptive	19	31.7
Formative/Design-Based Research	4	6.7
Other	2	3.3
Measurement Validation	1	1.7
Meta-analyses	1	1.7

This sample also contained cross-sectional designs (*n* = 10), examining technology or media use in children across age groups. These studies were notable for their age-specific descriptions of children's access to and use of technology or media. Seven of the ten designs employed survey methodology and, within these studies, there were no instances of any direct observation of children using technology or media (e.g., Cristia & Seidl, 2015; Crux Research Inc., 2015; Kabali et al., 2015). Three remaining studies are literature reviews (Ólafsson, et al., 2013; Sherry, 2013; Slovak, Gilad-Bachrach, & Fitzpatrick, 2015). There were no longitudinal studies in this sample.

There was also variance in the approach to and reporting of reliability and validity across studies. For example, Moser and colleagues (2015, p. 142) report interrater Kappa coefficients to the "acceptable level of .70" for their gesture and goal coding scheme, whereas Roseberry, Hirsh-Pasek, & Golinkoff (2014) acknowledge a second coder, but do not report reliability data. Further, research employing a case approach (e.g., Danby, Davidson, Theobald, Houen, & Thorpe, 2017) do not typically report such data. Survey instruments employed in the research analyzed seldom report validity statistics (Alpha values). As one example, Kabali and colleagues (2015, p. 2) report "the questionnaire was determined to have face validity by senior faculty, but was not tested for reliability".

Screen Time

See Table 3 for the frequency of entries specifying time for use within a single use or session. The studies reported that the majority of young children's technology or digital media interactions lasted less than 20 minutes. Fewer studies described or reported any disaggregated data specific to a child's interaction with technology or media that extended beyond 45 minutes. When these lengthier times for interaction were observed, the adult's mediation of a child's interactions with technology and media varied. For example, Wohlwend (2013) described how teachers in preschool through first grade (3-7 years) implemented a "literacy playshop"—a curricular unit focused on building from children's expertise, encouraging critical awareness of commercial messaging in popular media, and integrating filmmaking as a media for producing texts. The teachers asked children to plan for their story productions on paper first, but ultimately utilized the entire writer's workshop period (described in preschool as a "45 minute" period (p.26)) for the filmmaking piece of the unit. Bleakley Jordan, and Hennessy (2013) document that parents of children birth-5 years watch television for 2.34 hours across devices and have reported that nearly 85% often or sometimes co-view with their children. This variation of time spent on digital or electronic devices requires further exploration to understand the role of social participation and active engagement with the digital material.

Table 3. *Context: Frequency of Entries Specifying Time for Use Within a Single Use/Session*.

	Infant *n* = 16	**Toddler** *n* = 27	**Preschool** *n* = 52
< 5 mins	2	2	2
5-10 mins	0	1	1
11-20 mins	1	9	9
21-45 mins	1	4	4
46+ mins	2	5	5
unable to code	10	14	26

Task Environment

When a single technological device was named in the studies discussed here, tablets (*n* = 19, 31%) or desktops or laptops (*n* = 8, 13.3%) were most commonly utilized. Parallel to this, we identified an additional 31.7% (*n* = 19) of the studies examining children's use of multiple device types (Table 4), which were most common in descriptive studies. Such studies tended to employ cross-section to examine a child's access to and use of a range of technologies, rather than as description of a child's use of a range of technologies. In other words, there is a preponderance of research we describe as device agnostic. These studies examine the range of devices children have access to and as a result, examine how often children use the devices rather than examine what kinds of experiences they have with the device.

Table 4. *Research Design: Device Types.*

	Number of Entries/Category	Percent of Entries/Category
Multiple device types	19	31.7
Tablet	19	31.7
Unspecified	4	6.7
Desktop computer	5	8.3
TV or DVD	9	15
Laptop computer	3	5.0
Game console	0	0
Mobile/smart phone	0	0
Interactive whiteboard	0	0
Robot (tangible technology)	1	1.7
Digital camera	0	0

The most commonly occurring task types were those that involved a literacy-related focus (*n* = 31, 51.7%) (reading, writing, listening, speaking). There were far fewer instances of math (*n* = 17, 28.3%) and fewer still instances of science (*n* = 8, 13.3%) or the arts as the identified goal/objective for the child's interaction with technology or digital media within the data set.

Within the 60 studies sampled for the present study, children were engaged with technologies and media in many physical places including homes (*n* = 20, 33%), schools or childcare centers (*n* = 18, 30%), university laboratories (*n* = 11, 18.3%), or across multiple contexts (*n* = 5, 8.3%). There were few instances of research within family childcare settings, libraries, or other community contexts (e.g., churches, museums) (*n* = 1, 1.7%).

Social Context

A majority of the entries contained adults as part of the child's interaction with technology or media (Table 5). Only 6 (16.7%) of the entries were found without an adult as part of the interaction.

Table 5. *Social Context: Adults Coded as Part of Child's Interactions with Technology or Media.*

	Number of Entries/Category	Percent of Entries/Category*
No Adult	6	16.7
Parent/Guardian	28	46.7
Teacher/Child Care Provider	19	31.7
Interventionist/Therapist	4	6.7
Other Adult	8	13.3

Note: *Adult categories were not coded as mutually exclusive, so each row can be 100% itself.

Children received "some adult support" for a specific and described instance of their technology or media use in 35% of the entries coded for the current analysis and there were "significant amounts of support" for children's use of technology or media in 35% of the entries. Approximately 18% of the entries we coded for this paper did not provide sufficient elaboration regarding a child's encounter with technology or media to draw conclusions about the extent to which the 0-5 year old child's interactions were supported.

Our findings demonstrated that 31.7% of the entries we coded for this paper included specific examples of joint use of technology or media (child-adult or child-child) whereas 23.3% of the entries coded included specific examples of children using technology or media independently without any social interaction from others.

Through our integrative review (*n* = 60), we demonstrate the wide range in methodological approaches present in the existing enquiry around children's use of technologies and digital media early in life, specifically within the first five years of a child's life.

Discussion

Our review identified the range of research designs employed to study young children's interactions with technologies and digital media. Our review also presents a bird's eye view of the range of methodological features employed to study such interactions. We discuss our results within a framework that attempts to capture the complex interplay between child development, learning, lived experiences, and social contexts that surround the use of digital technologies.

Most Studies of Digital Technologies Examine Homogenous Populations

A key finding described the sample characteristics of the children that were studied. Many of the children were from homogenous populations, typically those from middle-class (e.g., Beschorner & Hutchinson, 2013). There was little discussion or special attention given to children from various demographics. Given that socioeconomic status (SES) is associated with several cognitive, social, educational and socioemotional outcomes in children (Bradley & Corwyn, 2002), it is imperative to encompass a wider variety of sample characteristics. For example,

the frequency of research participants from low socioeconomic backgrounds, English language learners, or diverse needs and rights should be increased.

Recent reports continue to find a digital divide (Guernsey & Levine, 2017); that is, there are differences in technology adoption between lower- and higher-income households (Common Sense Media, 2013). In the United States, about 65% of adults with household incomes less than $30,000 own a smartphone compared to 95% of adults with household incomes of $100,000 or more (Anderson, 2017). Thus, given SES relates to not only developmental outcomes, but also differences in technology adoption and ownership, it is important for researchers to collect demographic information and ensure a diverse sample is represented in the study. The selection of research participants from the primary sources that we reviewed may not reflect the reality of demographics in the US and in other countries. Children from low-income households are more likely to complete passive tasks, such as watching a show without participating, while children from higher income households are more likely to use technology to complete active tasks, such as using an app to draw a picture (Departments of Education and Health and Human Services, 2016).

While some researchers have suggested that it might be too difficult to measure use and familiarity with digital devices and activities, other researchers have recently argued that quantifying the child's use of media is beneficial (Rideout, 2016; Vandewater & Lee, 2009). A recent study demonstrated the importance of documenting media usage. Kirkorian and Choi (2017) found a relation between the amount of time children spent on interactive technologies predicted screen-based learning in a laboratory setting. Documenting the frequency and amount of media usage, which may also be used as a proxy for familiarity with various digital technologies may carry over into other research findings.

Most Studies OF Digital Technologies Adopted Comparative and Descriptive as Primary Methods

As shown in Table 2, 65% of the work in this space is either comparative or descriptive in nature. For example, Sobel, Recor, Evans, and Kientz (2016) compared neurotypical and neurodiverse children on their inclusion of peers in app-based co-play. By varying how the application utilized its programmed features to facilitate cooperation between typical-diverse dyads, Sobel and colleagues (2016) found that, while facilitated cooperation helped pairs who had trouble playing together, the same design limited creativity for pairs who did not need such scaffolding. Lozano and Ponciano (2016) compared the academic readiness of children as a function of their use of a digital learning resource for early education, finding that preschoolers who engaged more frequently with the digital learning resource were more ready for Kindergarten than those children with low usage of the same resource.

Parallel to this finding, several studies also employed cross-sectional design. The research instrumentation utilized across the studies in this sample relied on survey methods to gather data, rather than direct observation of the child or child-parent interaction around the digital media. Few studies observed how young children interact with interactive technology and studies that do include direct observation either assess differences between children and adults (Anthony, Brown, Nias, Tate, & Mohan, 2012) or study older children (Arif & Sylla, 2013; McKnight & Cassidy, 2010). The studies that have documented interactions with technology have focused on mixed methods, including both quantitative and qualitative analyses (e.g., Aziz, Batmaz, Stone, & Chung, 2013; Hamza & Salivia, 2015; Hourcade, Mascher, Wu, & Pantoja, 2015; Merchant, 2015).

Studies of Digital Technologies Contain Variation in Task Environment

We also found that children are using digital technologies in a variety of contexts with various content. Table 3 depicts the device type and shows that tablets and desktop computer/laptop and multiple device types were used in studies. In addition, most studies featured tasks that involved literacy, math and science. Finally, most of the studies occurred either in home, lab or education settings.

As Guernsey (2012) suggested, understanding the "three C's" which include the content, the context and the child is important to capture to understand how technology may strengthen the child's relationship with themselves and others. Likewise, we suggest that it is important to document the content (i.e., activity or tasks) that children are using and interacting with on devices. Recently, many authors have suggested that the design features of an

app or game play a key role in child-computer interactions (e.g., Miller & Kocurek; 2017; Paciga, 2015; Palmér, 2015). Much of the research on children interacting with digital technologies typically use one of two activities, either those that are commercially available in one of the app stores or one that is customized for the study. Engagement with multi-touch devices is heavily dependent on fine motor skills. When compared with traditional technologies, multi-touch devices can elicit an infinite number of movements (Yu, Zhang, Ren, Zhao, & Zhu, 2010). As a result, a significant challenge is determining the range of suitable fine motor hand movements for young children to use on multi-touch technologies, when they, themselves, are still acquiring fine motor skills. For example, Hiniker and colleagues (2015) provide a nice outline of the relation between design and specific motor skills needed to complete the activity. They examined the effectiveness of three different prompt (i.e., audio) techniques to test how children interact with apps; results demonstrated that age influenced the effectiveness of prompt type such that older children understood more types. Their results demonstrate the need for design to take into account developmental principles.

Most Studies of Digital Technologies Feature Children Interacting with Social Partners

The review also described the social context; that is, how children's interactions with technology and media intersected with their social environments. There was variation in the type of individual children were using technology with (e.g., therapist, parent, teacher). Furthermore, when adults did interact with the child, there was also variation in the level of support given to complete the task. Adult social behavior ranged from providing some support so that children were oriented to the tasks to providing ongoing support and scaffolding during the duration of the child's interaction with the device. Children who received support from an adult mentor displayed an increase in kindergarten readiness skills and positive attitudes towards learning compared to children who did not have support from a mentor (Primavera, Wiederlight, & DiGiacomo, 2011).

Research increasingly is recognizing that these interactions do not occur within a social vacuum. Young children are shaping their encounters with digital media through relational encounters with adults and peers/siblings who become co-participants (e.g., Danby et al., 2013). Many social interactional studies of digital participation in family contexts highlight the complexity of family practices through discourse analytic and socio-cultural frameworks (e.g., Marsh et al., 2015; Plowman, McPake, & Stephan, 2010). These studies focus on the social and relational elements, with digital media as a resource. Emerging research exploring intergenerational family relationships with digital technologies includes Aarsand's (2007) study of grandparents, parents and children orienting to the notion of a digital divide, with children expert game players and adults not. As well, digital telecommunication innovations produce social contexts for families' social interactions with digital technologies. Missing are studies of the babies and toddlers, although evidence shows that they are digital technology users (see Myers, LeWitt, Gallo, & Maselli, 2016).

We call for methodologies to actually focus on social interactions as they unfold. This approach requires capturing the moment-by-moment interactions of the children's engagement unfolding through the social context (for additional information see Miller, 2014; Miller & Gros-Louis, 2013; Miller & Lossia, 2013). For example, exploring the scaffolding that occurs between the child and others may provide insights into how adults (teachers / parents / peers / siblings) provide the relevant support at the right time (e.g. physical, verbal) and support educators to assist with children's learning when using digital devices. Engagement can be observed through understanding the diversity and elaboration of language that is being used by the child with co-present adults, peers and siblings; question-answer sequences, problem solving, new concepts introduced and discussed through digital exploration, and relational and social support.

Limitations

Our review and findings, however, are not without limitations and there are a few worth detailing here. First, our use of the broad and large sample of literature identified in Paciga and Donohue (2017) did not allow us to drill down specifically into any single topic within the early childhood technology/media research space. As such, our study and discussion offer only a bird's eye view of the methodologies applied by the field and what has been done, rather than a narrow and deep study of one specific outcome. Second, we could have systematically overlooked a portion of the infant/toddler and preschool literature by sampling from within the Paciga and Donohue (2017) set from Table 1. In other words, perhaps a wider range of empirical studies would have

emerged had we sampled from within the 595 studies originally identified, rather than conducting the present analysis from a portion of the existing sample set described in Paciga and Donohue (2017). Third, our classifications of the screen time and social context variables for study were difficult to apply to the primary sources analyzed, largely due to the lack of consistency in reporting these variables across the primary studies reviewed.

To summarize, children's digital experiences present topics for research exploration, and also a research context underpinned by ethical principles and procedures being reconfigured to take into account the children's digital footprint. Increased digital access to Internet-enabled activities and publicly available social media data require refiguring to identify ethically encompassing strategies for data collection (Common Sense Media, 2013; Chaudron, 2015; Danby, 2017). Ethical concerns usually are variations on existing ethical procedures, such as access to gatekeepers and gaining consent for the study to proceed, but there are challenges with working within this relatively unchartered context. One challenge is the use of screen images; at times copyright permission can be sought and obtained, but it may not always be possible to obtain written authorization to use digital online images for publication (Danby, 2017). Similarly, there are challenges with accessing and negotiating with gatekeepers the use of publically accessible data such as Facebook, blogs, and images/features of commercial and not-for-profit Internet applications. While online materials and social media sites are age-restricted and thus not necessarily sites of research for children's digital activities, adults (including parents and educators) are constructing online digital presences for their children, which are potential research sites (Danby, 2017; Nansen, 2015).

Studying young children's interactions with technologies and media is a complex endeavour for myriad reasons. In this paper, we have outlined the research methodologies utilized in more current studies on technology use with young children; namely, since the release of the iPad and other tablets in 2010. Within these methodologies, we have articulated essential considerations for understanding the ways in which children use digital technologies. Specifically, usability is a primary concern, from a developmental perspective. Not only should researchers be documenting the history of children's experiences with devices, but they should also be cognizant of the role of physiology: the development of fine motor skills, as well as larger muscular and postural changes, will naturally constrain the ways in which young children are physically able to interact with digital technology. Additionally, the social landscape must be considered. Young children are rarely using digital devices in isolation. More often than not, these children are engaging with peers, siblings, parents, and extended family members around technology. These social interactions must have a profound impact on how children are interpreting and learning from these experiences.

Notes

1. Digital technologies will refer primarily to touch screens, such as smartphones (e.g., iPhone) and tablets (e.g., iPad). Yet, we acknowledge the extensive coverage of other technology, including but not limited to computers (i.e., desktops) that have paved the way for the exploration of touch screens (Hughes & Hans, 2001; Wartella & Jennings, 2000; Yelland, 2005).

2. For detailed list of references included in the present synthesis, see Appendix.

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Appendix: Primary Sources Coded in Literature Review

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