The influence of TPACK contextual factors on early childhood educators' tablet computer use

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A B S T R A C T

Tablet computers are increasingly becoming commonplace in classrooms around the world. More than half of early childhood educators in the U.S. now have access to tablets, making it imperative to understand how they are using the device and what influences such use. The current study draws on survey data from 411 preschool educators serving 3- to 5-year-olds in school-based, center-based, and Head Start preschool programs to investigate how TPACK contextual factors (e.g., student background, teacher attitudes, and school support) influence teachers' traditional and student-centered tablet computer practices. Results suggest that teacher-level factors—especially positive attitudes toward technology—are most influential. Overall, this study emphasizes the need for preschool teachers and teacher educators to understand and address the critical contextual factors of tablet computer use in preschool education. Implications for education policy include expanding traditional funding models beyond technology access to provide on-going educator support, and developing new initiatives that encourage novel professional development models based on the same learned-centered practices that teachers are encouraged to use themselves.

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1. Introduction

Tablet computers are increasingly becoming a mainstay in classrooms worldwide (e.g., Coughlan, 2014; Fischer, 2015; Viriyapong & Harfield, 2013). In the United States in particular, more than 2200 K-16 institutions have Apple iPads (Apple, 2013). By 2016, 54% of U.S. K-12 students and teachers are projected to have access to 1:1 mobile devices (Fischer, 2015). While technology has traditionally been less prevalent in early childhood education (Vockley & Lang, 2011; Wartella & Robb, 2007), there has been a two-fold increase in the presence of tablet computers in early childhood classrooms since 2012 (Blackwell, Wartella, Lauricella, & Robb, 2015). While televisions, computers, and digital cameras still dominate, tablet computers are now accessible to over 50% of U.S. early childhood educators (Blackwell et al., 2015).

Increases in early childhood educators' tablet computer access comes at a time of shifting policy recommendations that now recognize the value of technology for young children's learning and development. In 2012, the National Association for the Education of Young Children (NAEYC, 2012) released a position statement supporting the developmentally appropriate and intentional use of technology in early childhood education, which included using technology as a tool to support social

interactions, provide opportunities to decrease the digital divide, and to individualize learning. Even the American Academy of Pediatrics (AAP, 2015), which for the past 15 years has cautioned against screen time use in early childhood, recognized that strict limits on children's screen time was no longer plausible in today's media-saturated world. The AAP (2015) went so far as to explicitly recognize decades of research showing high-quality educational media can have positive effects for young children's cognitive and social development (e.g., Fisch & Truglio, 2001; Jennings, Hooker, & Linebarger, 2009; Pasnik & Llorente, 2013) and shifted its policy recommendations to acknowledge that, when used with caregiver guidance and in moderation, along with quality content, screen time is not necessarily harmful—and in some cases beneficial—to the health and wellbeing of young children.

In light of these shifting views regarding general technology use in early childhood, tablet computers have been described as particularly suitable for early childhood. Unlike traditional desktop or laptop computers, tablets are easier for young children to use due to the technology's smaller size and touchscreens, which allow for direct manipulation (Neumann & Neumann, 2014; Tootell, Plumb, Hadfield, & Dawson, 2013). Tablets are also cognitively simpler and more intuitive than prior technologies because there is no mouse, making them better suited for young children who have not fully developed their motor skills and hand-eye coordination (Geist, 2012; McManis & Gunnewig, 2012). As Siegle (2013) suggests, tablet computers are easily accessible to young children "because the tap and swipe gestures used to manipulate virtual objects on a tablet computer can be made very similar to the kinds of gestures that children would spontaneously use on physical objects in the real world" (p.146). These unique affordances of tablet computers is reflected in the two-fold increase in early childhood educators' access to tablets, from 29% in 2012 to 55% in 2014 (Blackwell et al., 2015).

As tablets continue to saturate the early childhood education sector, it is no longer sufficient to understand *whether* teachers have access to this technology; rather, *how* teachers use tablets and the factors that influence such use are critical to understanding the potential effects tablets may have on teaching and learning. As such, the purpose of this study is to examine the relationship between TPACK contextual factors—and thus effective technology integration practices (Mishra & Koehler, 2006)—and the specific ways in which early childhood educators integrate tablet computers into the learning environment. Ultimately, this study will provide a better understanding of the student-, teacher-, and school-level factors on tablet computer integration in early childhood, with implications for teacher education and policymakers who seek to ensure effective technology use in early childhood education.

1.1. Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) is based on Shulman (1986; 1987) Pedagogical Content Knowledge (PCK) framework and describes the knowledge required to effectively teach with technology (Mishra & Koehler, 2006). Specifically, teachers need to know how technology can 1) enhance the representations of specific content and make subject matter easier or harder to learn; 2) be matched with specific pedagogical practices that enhance the teaching of specific subject matter; and 3) build on students' prior knowledge and instigate new learning (Koehler, Mishra, & Cain, 2013; Mishra & Koehler, 2006). TPACK is broader than just having technology knowledge, content expertise, or pedagogical expertise, as it focuses on the complex relationship that exists between all three components (Koehler et al., 2013; Mishra & Koehler, 2006). Importantly, and where TPACK differs from prior educational technology frameworks, is the acknowledgement that teaching and learning occur in specific contexts, and such contexts influence the development of TPACK and thus the effective use of technology (Rosenberg & Koehler, 2015).

Despite the importance placed on context, the original TPACK framework only described context as student background, grade level, subject matter, and available technology (Mishra & Koehler, 2006), leaving room for others to develop more complex understandings of what contextual factors are and how they influence TPACK (e.g., Angeli & Valanides, 2009; Kelly, 2010). Porras-Hernandez and Salinas-Amescua (2013) provide the most advanced description, taking an ecological approach by defining three hierarchical levels of context. For the purposes of this paper, we focus on the first two levels—the micro and the meso. The micro-level represents the classroom conditions (learning resources, classroom norms, student-teacher interactions), while the meso-level represents the school and local community environment (e.g., school and district leadership and support, local social, political, and/or economic conditions). For example, at the micro-level, teachers may lack access to sufficient hardware and software, while at the meso-level, school leaders may not provide quality training and support, both of which will undoubtedly influence a teacher's ability to integrate technology effectively, and thus his/her TPACK. Additionally, Porras-Hernandez and Salinas-Amescua (2013) emphasized the importance of considering how student and teacher characteristics influence TPACK. For students, their individual needs, interests, prior knowledge, and sociocultural background can influence how teachers design lessons, including how they choose to incorporate technology into the learning environment. For teachers, factors such as technology self-efficacy, attitudes toward technology, and general pedagogical beliefs all can influence TPACK. Thus, not only is it critical to approach TPACK context from various ecological levels but also to understand the intrinsic factors of students and teachers as these can have strong implications for how technology is integrated and the effectiveness of such integration (Porras-Hernandez & Salinas-Amescua, 2013).

For early childhood educators in particular, contextual factors may be even more important given the continued debate over the place of technology in the lives of young children. At the micro-level, particular student and teacher factors are critical to informing technology use in early childhood education. At the student-level, concerns over potential negative effects of technology tend to dominate discussions given early childhood being a critical period. Young children have always been viewed as a vulnerable population in the U.S. when it comes to media (Wartella & Robb, 2007), leading to

recommendations for no or limited screen time (American Academy of Pediatrics, 2013) and a continued emphasis on using technology in developmentally-appropriate ways in early childhood (NAEYC, 2012; Guernsey, 2007). At the same time, early childhood educators acknowledge the value of using technology to decrease the digital divide and to provide differentiated learning experiences based on children's individual needs (NAEYC, 2012).

At the teacher level, educators have traditionally been unsure of how to incorporate educational technology into their practice (Thorpe et al., 2015; Turja, Endepohls-Olpe, & Chatoney, 2009), with early childhood educators often lagging behind their K-12 counterparts in the amount and quality of technology integration (e.g., Thorpe et al., 2015; Vockley & Lang, 2011). Of note, teachers' deep-seated beliefs about what early childhood education are often in contrast to how they view technology (e.g., Cordes & Miller, 2000; Lindahl & Folkesson, 2012). As Donohue (2015) describes, in addition to concerns over inappropriate content and commercial messaging, technology is often viewed as displacing or interrupting social interactions, imaginative open-ended play, and active learning, all of which are traditional essential components of early childhood education. Further, some argue that technology displaces children's physical activity and time spent outdoors, which could contributes to "Nature-Deficit Disorder," or the negative physical, mental, and behavioral health effects that occur from a lack of engagement with the natural environment (Louv, 2005/2008).

As such, attitudes toward the value of technology and pedagogical dispositions may be even more important to early childhood educators' technology use compared to teachers of older children. Indeed, Blackwell, Lauricella, and Wartella (2014) showed that attitudes had the strongest effect on early childhood educators' technology use, and Lindahl and Folkesson (2012) found that preschool teachers integrated computers in ways that aligned with pre-existing pedagogical beliefs. Similarly, Tondeur, Hermans, van Braak, and Valcke (2008) highlighted the relationship between pedagogical beliefs and elementary teachers' computer integration, finding teachers with more traditional beliefs used computers as learning tools for skill and drill practice, while those with more constructivist pedagogies used computers as information tools for higher-level learning. Teachers in Thorpe et al. (2015) study simply chose not to integrate Internet searching activities into their instruction because they were unsure about the Internet's pedagogical role in early childhood education. Further, technology competency and confidence have also been associated with early childhood educators' technology use (Blackwell et al., 2014; Blackwell, Lauricella, Wartella, Robb, & Schomburg, 2013; Karaca, Can, & Yildirim, 2013). Together, these studies suggest intrinsic characteristics are important and need to be accounted for to fully how and why teachers integrate technology into the classroom.

At the meso-level, school factors also play important roles in early childhood educators' technology integration. In the U.S., early childhood education presents a unique environment given the lack of universal preschool, such that teachers operate in distinctive types of programs that may offer different climates and conditions for using technology. For example, Wartella, Blackwell, Lauricella, and Robb (2013) found that teachers in center-based programs (i.e., for- or non-profit non-school based care such as Bright Horizons, Montessori, and YMCA) were more likely to *never* use tablet computers compared to teachers in school-based programs (i.e., public or private programs within K-12 school programs). While the majority of teachers in this study taught more than one age group, there were no differences in the proportion of teachers serving 3 to 6-year-olds at center- and school-based programs, such that differences in child age is unlikely responsible for differences in use. Additionally, factors such as school support and a shared vision for technology use also influence early childhood educators' technology use (Blackwell et al., 2014; Karaca et al., 2013).

1.2. Tablet computer use in early childhood education

Prior research suggests that while technology is more often integrated as digitized skill and drill activities (e.g., Eteokleous, 2008; Project Tomorrow, 2011), the most effective integration practices use technology to support student-centered instruction (Li & Ma, 2010; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011). Specifically, technology is thought to be most effective when the learning focus shifts from the teacher to the student, with student interests and abilities guiding the content, pace, and learning activities (Jones, 2007). This is opposed to more traditional didactic approaches where students primarily use technology to acquire basic skills and pre-specified content knowledge through drill and practice (Eteokleous, 2008).

For tablet computers in particular, teachers use this technology in a variety of learning contexts, some of which replicate more traditional practices and others that embody student-centered learning. A recent survey conducted by the Joan Ganz Cooney Center on K-8 teachers found the most frequently reported use of tablet computer games was to practice material already learned (43%) and as a reward (33%; Takeuchi & Vaala, 2014), suggesting these teachers are not using tablets to support more student-centered practices. On the other hand, Beschorner and Hutchison (2013) observed that teachers of preschoolers integrated tablets during center time where children could choose any app to play with, small group time where several students listened to stories or played apps together, and whole group teacher-led activities, suggesting a mix of traditional and student-centered learning processes.

Early childhood educators also integrate tablets across subject areas (e.g., Beschorner & Hutchison, 2013; Janke & Kumar, 2014; Lui et al., 2014). In a survey of over 1400 educators of birth to age 8, Wartella et al. (2013) found that the large majority of teachers used tablets for teaching academic content. Alternatively, others find that tablets are often integrated into creation activities in early childhood settings. Janke and Kumar (2014) observed preschoolers using the *Book Creator* app to create digital book reviews, and Blackwell (2013) observed kindergarteners using the *SMART Notebook* app to create digital scrapbooks. Teachers have also reported using tablets to facilitate social interactions and encourage collaboration among

children (Beschorner & Hutchison, 2013; Henderson & Yeow, 2012). Indeed, recent research suggests that tablet computers are exceptionally well suited for student collaboration due to the touchscreen and size of the device (Chou, Block, & Jesness, 2012; Henderson & Yeow, 2012), and paired tablet use may even promote positive cognitive and social-emotional development (Blackwell, 2015; Gomez et al., 2013).

Despite the diverse use of tablets in both traditional and student-centered learning practices, when it comes to selecting specific content, teachers are left in what Guernsey, Levine, Chiong, and Severns (2012) refer to as the "fast evolving and chaotic Wild West of digital apps" (p.15); educators have many products to choose from but little information on whether and how these digital tools enhance learning (Cherner, Dix, & Lee, 2014). While frameworks and evaluation rubrics have proposed specific design features that may promote learning—such as scaffolding, audio and visual cues, interactivity, and opportunities for collaboration (e.g., Cahill & McGill-Franzen, 2013; Falloon, 2013; Hirsh-Pasek et al., 2015; More & Travers, 2013; Neumann & Neumann, 2014)—the currently available "educational" apps rarely align with these suggestions nor is there a unified definition of educational quality (e.g., Murray & Olcese, 2011; Vaala & Ly, 2014). As a result, several researchers have tried to categorize apps (e.g., Cherner et al., 2014; Goodwin, 2012; Michael Cohen Group, 2011) or provide more information about apps in specific subject areas (e.g., Highfield & Goodwin, 2013; Shuler, 2012; Shuler, Levine, & Ree, 2012), but few have investigated what apps early childhood educators actually use in the classroom. While Takeuchi and Vaala (2014) surveyed K-8 teachers on their digital game selection, no survey of U.S. early childhood educators' app selection has been documented. Given the importance of media content to young children's learning (Guernsey, 2007), knowing what early childhood educators are using can provide realistic expectations for the effect of apps on children's learning as well as insight on ways to aid educators in selecting high-quality apps.

1.3. Current study

The main objective of the current study was to better understand the relationship between TPACK contextual factors and specific tablet computer practices that reflect traditional and student-centered teaching with technology. Additionally, given the dearth of research on the specific content that educators actually use in the classroom, such that the secondary purpose of this study was to provide information on the specific apps and app types that early childhood educators use. Specifically, we ask:

1. What is the relationship between student-, teacher-, and school-level contextual factors and early childhood educators' use of tablet computers?
2. What specific apps and app types do early childhood educators use in the classroom?

2. Methods

To address the above research questions, we developed an online survey based on a prior survey conducted by the authors in 2012. In collaboration with the National Association for the Education of Young Children (NAEYC), we emailed a link to the survey to the NAEYC member listserv. NAEYC is a professional membership organization promoting high-quality early childhood education through professional development, accreditation of early childhood programs that meet NAEYC standards, and public policy advocating and recommendations (see www.NAEYC.org for more information). The 70,000 NAEYC members across the United States represent university faculty, researchers, and teacher educators in addition to early childhood educators working with young children. Participants were screened, such that only educators working directly with children ages 0 to 8 were included, with a final sample of 945 participants.

2.1. Participants

For the current study, a subsample of the 945 respondents was selected based on three criteria: 1) being a teacher of children ages 3 to 5; 2) being a teacher in a Head Start, school-based, or center-based program (i.e., *not* a home-based care provider); and 3) having access to tablet computers. The final sample included 411 participants (43.49% of the original sample) who met these criteria. The majority was female (96.3%) and white (90.1%). Most teachers had a Bachelor's (37.7%) or Master's degree (50.4%), and on average 21.41 years (SD = 10.53) of teaching experience. Respondents worked in a variety of programs—Head Start (11.7%), center-based (37.2%; i.e., for- or non-profit non-school based care), and school-based (51.1%; i.e., public or private programs within K-12 school programs)—and 46.5% taught low-income children.

2.2. Measures

2.2.1. Dependent variables

Frequency of use described how often teachers used tablet computers for instructional purposes with their students, defined as "using technology with students to reinforce a curricular goal" and measured on a 7-point Likert scale anchored by *never* and *daily*. This scale was converted into days per month to provide a more practical interpretation: *never* (0), *less than once a month* (0.5), *once a month* (1), *2–3 times a month* (2.5), *once a week* (4), *3–4 times a week* (14), and *daily* (30).

Type of use described how often teachers integrated tablets for six specific practices measured on a 4-point Likert scale anchored by *never* and *always*. Student-centered learning practices included using tablets for individual learning, paired learning, creation activities, and free play (Jones, 2007). Traditional practices included using tablets for practicing material already learned and basic technology user skills (Eteokleous, 2008). Binary variables were computed to represent whether or not teachers ever used tablets in these ways because nearly half of teachers reporting *never* using tablets for these six practices (Table 2). Importantly, this measure was completely separate from the content measure regarding specific apps (described above) and thus the app categories described in Table 1 do not map onto the student-centered and traditional practices described here.

2.2.2. Independent variables

Independent variables described contextual factors at the student-, teacher-, and school-levels.

2.2.2.1. Student-level. **Student-income** described teachers' report of their students' income level using McManis, Simon, & Nemeth (2012) 5-point Likert scale: *low-income, low-middle-income, middle-income, upper-middle-income, and upper-income*. For ease of interpretation, these categories were condensed to three binary variables: *low-income*, which included low- and low-middle-income; *middle-income*, which included only the middle-income variable; and *high-income*, which include middle-high-income and high-income. For all regression analyses, *low-income* was the reference category.

2.2.2.2. Teacher-level. **Technology confidence** described teachers' confidence using tablets in developmentally-appropriate ways on a 5-point Likert scale, anchored by *not at all confident* and *very confident*.

Pedagogy described the extent to which teachers held traditional pedagogical dispositions and was measured using Stipek and Byler (1997) basic skills pedagogy scale (14 items, Cronbach's alpha = 0.88). The scale included eleven basic skills items (e.g., "Worksheets and workbooks are a good way for children to master academic skills such as math") and three child-centered items (e.g., "Teachers should not emphasize right and wrong answers"), all measured on a 5-point Likert scale anchored by *strongly disagree* and *strongly agree*. A factor analysis with varimax rotation was conducted and forced to two factors given the two underlying constructs of *basic skills* and *child-centered pedagogies*. Two factors emerged with eigenvalues greater than 1, and all items fell on their respective basic skills or child-centered dimension with a factor loading of 0.6 or greater on one component and 0.4 or smaller on the other component. The one exception was the child-centered item, "Formal instruction in math- and reading-related skills should only be given if children want it," which did not load on either factor. The two factors accounted for 47.24% of the variation. Weighted factor scores were calculated, such that each teacher had a score for traditional pedagogy and one for child-centered pedagogy.

Teacher technology attitudes were measured using a validated 9-item index of teacher attitudes toward the affordances of technology integration (Cronbach's alpha = 0.89; Blackwell et al., 2013; 2014), measured on a 5-point Likert scale anchored by *strongly disagree* and *strongly agree*. A factor analysis with varimax rotation was conducted and resulted in two factors with eigenvalues greater than 1, where each item had a factor loading of 0.6 or greater on one component and 0.4 or smaller on the other component. Five items loaded on the first factor—*technology for children's learning*—and described how technology could be useful to children's cognitive and social development (e.g., "Technology can help to develop children's critical thinking skills" and "Technology is useful for social interactions among children."). Three items loaded on the second factor—*technology for administration*—and described how technology could aid teachers in more administrative tasks (e.g., "Technology can improve my ability to communicate with parents and other caregivers"). The item "Technology is useful for assisting children with disabilities" did not load on either factor. The two factors accounted for 70.5% of the variation. Weighted factor scores were calculated, such that each teacher had a score for attitudes toward technology for children's learning and one for attitudes toward technology for administration.

Table 1
Description of app categories.

App category	Description	Example
Literacy	Apps that teach ABCs, phonics, writing or tracing letters as well as reading-type apps, such as storybook apps, e-books, and apps where children can read or listen to books.	*Starfall, RazKids, Handwriting Without Tears, Endless ABCs, Letter Quiz*
STEM	Apps that specifically address any of the four STEM content areas—science, technology, engineering, and math—as well as STEM-related skills, such as logic and problem solving (e.g., pattern, sorting, and puzzle apps).	*Elmo Loves 123s, Marco Polo Weather, Little Logic Problem Solvers, Montessori Math, Sort It Out*
General education	Apps that cover more than one academic topic. For example, *ABCMouse* has a range of games and activities that include both literacy and math skills. This category also includes general descriptions of apps that participants made, such as "letters and numbers apps" as well as non-content specific apps, such as *YouTube*.	*ABCMouse, PBS/PBS Kids, Bugs and Bubbles, Preschool Monkey Lunchbox, Hatch Early Learning, YouTube*

Table 2
Proportion of teachers who reported *never* or *at least sometimes* using tablets for six learning activities and practices.

	Never	At least sometimes	N
Individual learning	36.1%	63.9%	330
Creation activities	41.7%	58.3%	331
Paired learning	32.6%	67.4%	331
Free choice	45.3%	54.7%	333
Practicing material already learned	45.9%	54.1%	331
Basic user skills	34.1%	65.9%	334

2.2.2.3. School-level. Technology professional development described how frequently schools offered professional development in educational technology, measured on a 7-point Likert scale anchored by *never* and *weekly*.

School support for technology described the extent to which teachers perceived their school supported their educational technology professional development needs, and was measured with a validated 11-item scale (Cronbach's = 0.95; Blackwell et al., 2013; 2014). Each item was measured on a 6-point Likert scale anchored by *no support offered* and *very supportive*. Items described both structural supports, such as access to sufficient hardware and software, and pedagogical supports, such as finding quality digital content and providing developmentally-appropriate models of technology use. A factor analysis with varimax rotation resulted in one factor, such that an average of the 11 items was used to measure teachers' average perceived school support.

School Type described the type of program in which the educators worked: Head Start, center-based care, or school-based care. Binary variables were created for each program type, and center-based care was the reference category in all regression analyses.

2.2.3. App content

To better understand what tablet computer apps teachers use, we asked teachers to report up to three specific app titles. In total, 186 teachers reported 242 unique app titles or kinds of apps (e.g., games, photo apps). Due to this large variability, we only conducted descriptive frequencies for specific apps mentioned by at least 5% of teachers. Additionally, to obtain information on more general trends in app selection, the primarily researcher iteratively developed 13 app categories through open-coding of the full list of apps. A second researcher double-coded 20% of the sample and achieved an inter-rater reliability of 0.89. Because of the small sample size within categories, only the top three most commonly listed app categories were included in the analysis—early literacy apps, STEM apps, and general education apps (see Table 1 for a description and example of each category).

Of note, teachers used a broad definition of "app" that included pre-installed system-specific (e.g., Android, iOS) applications (e.g., Internet, weather, camera), web-based mobile apps that function as portals to access online content from a mobile device (e.g., *YouTube*), and non-web-based apps that, once downloaded, can be used without Internet access (e.g., *Bugs and Bubbles, Preschool Monkey Lunchbox*), including those that have companion websites (e.g., *Starfall, ABCMouse, Raz-Kids*). In our inductive categorization, we included all types of "apps" as this most accurately represented what early childhood educators view as tablet computer apps.

2.3. Analytic procedure

First, a linear regression was conducted to understand how contextual factors influence teachers' frequency of using tablet computers. Second, a series of logistic regressions with odds ratios were conducted to explore how contextual factors relate to whether or not teachers integrate iPads in the six specific practices described above. Nagelkerke R Square values were used to describe the variance explained in each model. Finally, we conducted descriptive frequencies to understand what specific apps and types of apps teachers select to use in their classrooms.

3. Results

3.1. Frequency of tablet computer use

On average, teachers reported using tablet computers for 12.16 days per month (SE = 0.62). Results from the linear regression showed specific student-, teacher-, and school-level factors influence how often early childhood educators use tablet computers (Table 3). At the student level, teachers of high-income students used tablets approximately six fewer days a month compared to teachers of low-income students. At the teacher level, both confidence and attitudes toward the affordances of technology to aid children's learning were positively associated with use; attitudes toward using technology for administrative purposes had a negative relationship. At the school level, frequency of professional development and being a teacher in a school-based program compared to a center-based program were positively associated with using tablets. Overall, the model explained 30% of the variation in teachers' frequency of using tablet computers.

3.2. Specific tablet computer use

Results from the logistic regressions showed few significant relationships for student and school-level variables, but teacher-level variables were consistently related to how teachers specifically integrated tablets into their classrooms (Tables 4 and 5). Overall, each model explained between 22% and 34% of the variability in teachers' likelihood to use tablet computers for each specific practice.

3.2.1. Student level
Teachers of middle-income students were less likely to use tablets for individual activities, to teach material already learned, and for creation activities compared to teachers of low-income students. Additionally, teachers of high-income students were less likely to use tablets for individual and free choice activities compared to teachers of low-income students.

3.2.2. Teacher level
Teacher attitudes had a strong relationship with teachers' likelihood to use tablets across all practices. Specifically, a one-point increase in *attitudes toward the value of technology to aid children's learning* was associated with being approximately twice as likely to use tablets for each practice. Alternatively, a one-point *decrease* in *attitudes toward administrative technology use* was associated with being 2 to 3 times more likely to implement tablet computers. Additionally, teachers' confidence in using tablets in developmentally appropriate ways was associated with using tablets for all practices except free choice. Of note, a one-point increase in confidence was associated with a 2.26 times higher likelihood to use tablets to teach basic technology skills. When it comes to pedagogy, a one-point *decrease* in *basic skills pedagogy* was associated with a 2.33 higher likelihood to use tablets for paired learning, while a one-point increase in *child-centered pedagogy* was associated with a 2.6 higher likelihood to use tablets for basic technology skills.

3.2.3. School level
Technology school support was only associated with student-centered practices. Specifically, a one-point increase in support was associated with a higher likelihood of using tablets for creation activities, paired learning, and free choice. Additionally, program type was associated with teachers' likelihood to use tablets to teach basic technology skills. Being a teacher in a school-based program was associated with a 3.07 times higher likelihood while being a teacher in a Head Start program was associated with a 1.54 times higher likelihood of using tablets to teach basic user skills compared to teachers in center-based programs.

3.3. App selection

There was great variation in specific apps listed, with only seven apps being named by more than 5% of teachers. Specifically, *PBS/PBS Kids* was mentioned most frequently (12.9%), followed by *ABCMouse* (10.22%), *YouTube* (9.14%), *StarFall* (8.6%), rhyming apps (6.98%), ABC apps (5.38%), and *Bugs and Bubbles* (5.38%). Of the 242 apps listed, 26.86% were early literacy, 20.25% were general education, and 19% were STEM apps. Slightly over half of respondents (54.8%) reported using at least one early literacy app, while 42.5% and 34.4% reported using at least one general education and STEM app, respectively. Only 5.4% of respondents listed all three types of apps. Because of the limited overlap of apps, differences could not be assessed as a function of student-, teacher-, and school-level factors.

Table 3
Linear regression predicting the frequency with which teachers use tablet computers for instruction.

	B	SE
Teaching experience	−0.02	0.07
Professional development	1.28*	0.63
Middle-income	−3.61	1.97
High-income	−5.96**	1.87
School-based care	3.73*	1.72
Head Start	0.84	1.32
Traditional pedagogy	3.09*	1.60
Child-centered pedagogy	0.13	1.87
Confidence	3.15**	0.82
Learning factor	3.99**	1.12
Administrative factor	−4.21**	1.34
School support	0.73	0.72
Constant	−8.70	6.76

Note. *p ≤ 0.05, **p ≤ 0.01.

Table 4
Logistic regressions for using tablets in traditional learning practices.

	Practice			Basic user skills		
	B	SE	Odds ratio	B	SE	Odds ratio
Tablet use per month	0.00	0.02	1.00	0.01	0.02	1.01
Teaching experience	0.02	0.02	1.02	0.02	0.02	1.02
Professional development	0.18	0.16	1.20	−0.02	0.17	0.98
Student income						
Middle-income	−0.96*	0.46	0.38	0.47	0.53	1.59
High-income	−0.21	0.44	0.81	−0.45	0.47	0.64
Program type						
School-based care	0.73	0.42	2.08	1.12*	0.47	3.07
Head Start	0.32	0.62	1.38	0.43	0.66	1.54
Traditional pedagogy	0.47	0.39	1.60	0.13	0.43	1.13
Child-centered pedagogy	0.47	0.43	1.61	0.96*	0.48	2.60
Confidence	0.44*	0.22	1.55	0.82**	0.24	2.26
Learning factor	0.80**	0.28	2.22	0.97**	0.31	2.64
Administrative factor	−1.15**	0.38	0.32	−1.11**	0.44	0.33
School support	0.26	0.18	1.29	0.30	0.19	1.35
Constant	−3.19	1.85	0.04	−5.15	2.11	0.01
Overall model summary						
Chi-square	46.98, df = 13			54.31, df = 13		
2 log likelihood	217.65			188.32		
Nagelkerke R Square	0.29			0.34		

Note. *$p \leq 0.05$, **$p \leq 0.01$.

Table 5
Logistic regressions for using tablets in student-centered learning practices.

	Individual learning			Creation activities			Paired learning			Free choice		
	B	SE	Odds ratio	B	SE	Odds ratio	B	SE	Odds ratio	B	SE	Odds ratio
Tablet use per month	0.01	0.02	1.01	−0.01	0.02	0.99	−0.01	0.02	0.99	0.01	0.02	1.01
Teaching experience	0.00	0.02	1.00	−0.02	0.02	0.98	0.02	0.02	1.02	0.00	0.02	1.00
Professional development	0.20	0.16	1.22	0.03	0.16	1.03	0.11	0.16	1.11	0.00	0.15	1.00
Student income												
Middle-income	−1.27**	0.47	0.28	−1.13*	0.50	0.32	−0.41	0.50	0.66	−0.58	0.46	0.56
High-income	−0.89*	0.45	0.41	−0.80	0.46	0.45	−0.67	0.47	0.51	−1.02*	0.44	0.36
Program type												
School-based care	−0.23	0.44	0.79	−0.47	0.45	0.62	−0.16	0.46	0.85	0.75	0.42	2.11
Head Start	−1.03	0.66	0.36	−0.97	0.65	0.38	−0.73	0.66	0.48	−0.25	0.60	0.78
Traditional pedagogy	−0.41	0.39	0.66	−0.72	0.39	0.49	−0.85*	0.40	0.43	−0.11	0.38	0.90
Child-centered pedagogy	0.49	0.44	1.63	0.10	0.43	1.10	0.61	0.45	1.84	0.64	0.43	1.90
Confidence	0.42*	0.22	1.52	0.64**	0.23	1.89	0.62**	0.23	1.86	0.22	0.22	1.25
Learning factor	0.81**	0.29	2.25	0.84**	0.30	2.32	0.61*	0.29	1.85	0.94**	0.29	2.57
Administrative factor	−0.91**	0.36	0.40	−0.97**	0.39	0.38	−0.84*	0.41	0.43	−0.78*	0.35	0.46
School support	0.13	0.17	1.14	0.60**	0.18	1.83	0.44*	0.18	1.55	0.56**	0.18	1.74
Constant	−0.43	1.81	0.65	−1.54	1.85	0.22	−1.80	1.91	0.17	−3.59	1.82	0.03
Overall model summary												
Chi-square	34.92, df = 13			44.15, df = 13			32.41, df = 13			47.33, df = 13		
2 log likelihood	215.06			211.87			203.45			221.05		
Nagelkerke R Square	0.23			0.28			0.22			0.29		

Note. *$p \leq 0.05$, **$p \leq 0.01$.

4. Discussion

Results from the current study support Porras-Hernandez and Salinas-Amescua (2013) suggestion that TPACK occurs within specific contexts, making it necessary to separate student-, teacher-, and school-level factors to understand educational technology integration. First, teachers lacked consensus in app selection, suggesting the need for support to ensure educators are using the highest quality apps available. Next, at the student level, teachers of low-income students integrated tablets more frequently and were more likely to use the technology to support student-centered learning practices; at the teacher level, attitudes toward technology, confidence, and pedagogy strongly influenced whether and how teachers integrated tablets; and at the school level, frequency of professional development was associated with how often teachers use tablets, while school support was associated with teachers' specific tablet computer instructional practices.

4.1. Student-level

Of particular note is the finding that teachers of low-income students not only used tablet computers more often than teachers of high-income students, but that they were more likely to use tablets for student-centered practices compared to teachers of middle- and high-income students. These findings contrast prior work often shows that teachers of low-income students primarily use technology for skill and drill work (e.g., Warschauer & Matuchniak, 2010).

One explanation for such findings may be due to teachers having different views about technology integration based on student-income. Blackwell et al. (2014) found that preschool teachers of high-income students had less positive attitudes toward the value of technology for children's learning and thus used technology less. Further, high-income students have more access to tablets at home, and their parents are much more likely to download educational apps compared to low-income parents (Rideout, 2013). High-income children also have more support and quality parent engagement both with and without technology compared to low-income students (Neuman & Celano, 2012; Phillips, 2011; Wartella, Rideout, Lauricella, & Connell, 2014), such that teachers of low-income students may see their role as being the provider of holistic technology experiences in the absence of such experiences at home. Finally, recent policy initiatives highlighting the importance of digital literacy for children's future academic and workplace success (e.g., Beauchamp, Burden, & Abinett, 2015; ISTE, 2007; NIL, 2008) and providing quality technology experiences to *all* children (e.g., NAEYC, 2012; Office of Head Start, 2012) may finally be trickling down to the classroom level. As such, results from the current study suggest teachers may be working toward a more integrated approach of technology use for low-income preschool children that goes above and beyond traditional skill and drill activities to foster more student-centered practices.

4.2. Teacher-level

Teacher contextual factors not only predicted how often teachers used tablets but consistently predicted the types of activities for which teachers used the device. Specifically, teacher attitudes toward the affordances of technology to aid children's learning was the strongest teacher-level predictor across all practices. Similarly, teacher confidence in using tablets in developmentally appropriate ways was associated with a higher likelihood of using tablets for all practices, with the exception of free choice. Alternatively, more positive attitudes toward using technology for administrative tasks was associated with a lower likelihood of using tablets for the six instructional practices. One potential explanation for this finding is based on prior research suggesting teachers align their technology use with their perceived value of the device to accomplish particular tasks (Blackwell et al., 2013; Lindahl & Folkesson, 2012; Tondeur et al., 2008). A such, teachers with more positive attitudes toward the administrative value of technology may use tablets to accomplish administrative tasks more so than they use tablets for instructional purposes, thus explaining the negative relationship.

Teacher pedagogy also influenced tablet use; however, pedagogy was only associated with two specific practices—paired learning and basic technology skills. While teachers with more basic skills pedagogies were less likely to use tablets for paired learning, teachers with more child-centered pedagogies were more likely to use tablets to teach basic technology skills—a practice originally hypothesized as a basic skills pedagogical practice. One plausible explanation for these results is that teachers equate basic technology skills with digital literacy in early childhood, which aligns more with student-centered pedagogy (Partnership for 21st Century Skills, 2009). Indeed, the National Institute for Literacy (NIL, 2008) suggests early digital literacy skills are analogous to early book handling skills, and the International Society for Technology in Education (ISTE, 2007) recommends that young children should learn these basic technology skills by the age of 5. This suggests that these basic technology skills are the foundation for more advanced digital literacy skills. As such, while learning basic technology skills at first appears to align with basic skills pedagogy, teachers may view these basic technology skills as more student-centered learning processes because such skills prepare young children for more advanced critical thinking and use of technology in the future.

4.3. School-level

While teachers with more professional development used tablets more frequently, they did not use tablets differently than teachers with less frequent professional development. On the other hand, while school support was not associated with the frequency of tablet use, it was associated with how teachers used tablets. Specifically, school support was associated with student-centered practices—including creation activities, paired learning, and free choice—suggesting that support may be critical for teachers to adopt more student-centered approaches with tablets. However, more detailed explorations of school support are required to better understand how specific support practices influence early childhood educators' tablet computer use.

4.4. Content

Descriptive findings suggest early childhood educators lacked a cohesive definition of what an app is as well as consensus on specific apps to use in the classroom. Indeed, many teachers interpreted "apps" in the broadest sense possible to include pre-installed applications, web-based mobile apps, and non-web-based that can be downloaded and used offline. Thus, from

a teacher's point of view (and likely the non-technical audience more generally), any program that runs on a tablet computer is an app.

When it comes to specific apps, results suggest that educators tended to favor early literacy apps, with slightly over half of respondents reporting at least such app. This finding supports Wartella et al. (2013) results where 79% of early childhood educators reported using tablet computers for literacy instruction. However, the most frequently reported app was only named by 24 of the 186 teachers, mirroring Takeuchi and Vaala (2014) study, where the most frequently reported digital game was only named by 26 of 264 K-8 teachers. Thus, while early childhood educators are somewhat more likely to select early literacy apps, there remains little agreement on specific app titles. This is not surprising given the extensive selection of apps (Shuler et al., 2012) paired with the lack of a unified definition of educational quality for apps (Guernsey et al., 2012).

Overall, results from the current study suggest that teacher-level factors (e.g., attitudes, confidence, pedagogy) are more strongly associated with tablet computer integration compared to student- or school-level factors (e.g., student income, support), a finding consistent with prior work (e.g., Blackwell et al., 2014; Ertmer & Ottenbreit-Leftwich, 2013; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). Given that the specific ways in which technology is used influences its effectiveness on learning (e.g., Li & Ma, 2010; Ross, Morrison, & Lowther, 2010; Tamim et al., 2011), this study suggests that developing teachers' positive dispositions toward the educational value of tablet computers as well as their student-centered pedagogies could help them integrate tablets in more diverse and potentially more effective ways in the classroom.

4.5. Policy implications

Given the two-fold increase in access to tablet computers from 2012, with over 50% of U.S. early childhood educators now having access to the device (Blackwell et al., 2015), policymakers should be aware of how teachers are integrating tablets into their classrooms and what factors influence such integration. First, a large number of teachers reported never integrating tablets in student-centered ways, despite research suggesting these are more effective than more traditional pedagogical practices (Li & Ma, 2010; Tamim et al., 2011). While NAEYC (2012) suggests that teachers use technology in developmentally-appropriate ways and TPACK literature suggests that effective technology integration needs to align with student-centered pedagogies (Koehler et al., 2013; Mishra & Koehler, 2006), it is clear from this study than many early childhood educators are not using tablet computers to support a student-centered learning environment. While policymakers can continue to make recommendations on *how* teachers should use technology, more work is needed to develop policies that ensure teachers have sufficient educational technology professional development to appropriately deliver on these recommendations.

Policymakers must also rethink technology investments to include both investments in the devices and investments in professional development. In particular, policymakers should focus on professional development that works to increase educators' attitudes toward the value of technology to aid children's learning, shift teachers' pedagogies to more student-centered dispositions, and provide information on specific quality digital content. Indeed, Pasnik and Llorente (2013) found that preschool teachers shifted their attitudes toward the value of educational technology when they received upfront and continual professional development in both technology use and curricular guidance. Others have suggested that professional development should include a hands-on approach where teachers have the opportunity to design and test their own digital content (Yeh, Hwang, & Hsu, 2015), explore and play with available content (Beauchamp, Burden, & Abbinett, 2015), and practice developing standards-aligned lesson plans that incorporate digital content (Mouza & Barrett-Greenly, 2015). Unlike traditional professional development programs that provide one-time trainings, these initiatives stress the importance of providing on-going support to teachers during the school year. As such, if the goal of professional development in educational technology is to shift teachers' attitudes and pedagogical dispositions to embrace more learner-centered practices, it follows that their training should also shift to a more learner-centered approach.

5. Limitations

While the current study provides novel evidence on the influence of TPACK contextual factors on early childhood educators' integration of tablet computers, several limitations should be noted. First, this study did not directly test TPACK as it relates to tablet computers but instead tested how TPACK contextual factors that were noted in the literature (e.g., Rosenberg & Koehler, 2015) influence how teachers integrate tablets in traditional and student-centered practices. As such, the current study cannot say whether or not these contextual factors directly influenced TPACK.

Second, the large proportion of teachers who reported never implementing tablets in the six practices made it necessary to only investigate whether or not teachers integrated tablets in these ways. The results do not provide evidence on the extent to which teachers integrated tablets in specific traditional and student-centered practices, as a continuous outcome variable would be necessary to provide such information. However, this is one of few studies to provide quantitative evidence on how teachers integrate tablets in specific practices versus just how often they use tablets in the classroom more generally. As such, while future research should aim to measure the extent to which teachers use tablets in traditional and student-centered practices, the current study provides an important first step.

Finally, the current study does not provide evidence on how TPACK contextual factors and the ways in which teachers integrated tablet computers influence student learning. While we can hypothesize that more student-centered learning practices will have larger positive effects on student learning based on prior research (e.g., Li & Ma, 2010; Tamim et al., 2011),

it is impossible to determine whether students whose teachers integrated tablets in more student-centered practices did better than students whose teachers did not use tablets in these ways. As such, future research should connect teacher-level variables of attitudes and pedagogy with student-level outcome data to better understand how teacher variables moderate the influence of specific tablet computer practices on student learning.

6. Conclusions

With the large increase in tablet computer access in the U.S. and worldwide, it is critical to understand the context in which these devices are being used. The current study provides novel evidence on how TPACK contextual factors influenced early childhood educators' use of tablet computers in traditional and student-centered practices. While TPACK has been applied to a variety of studies investigating teachers' technology use (for reviews, see Chai, Koh, & Tsai, 2013; Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013), few take into account particular technology devices or specific contextual factors as the current study does. Indeed, given that some contextual factors influenced certain practices but not others, the current study highlights the need to look more carefully at specific tablet computer integration practices and not treat technology or context as universal constructs. Importantly, this study suggests that attitudes toward the value of technology to aid children's learning are critical to understanding how teachers incorporate tablets into the learning environment. Shifting such attitudes has the potential to not only change how technology is integrated but also the effect of technology on student achievement.

Overall, this study will benefit teachers, teacher educators, and policymakers. First, teachers will better understand how contextual factors influence their digital learning practices, enabling critical reflection on attitudes, confidence, and pedagogical dispositions. Further, teachers will gain practical information regarding how to use tablets with young students to support student-centered learning endeavors.

Second, teacher educators will gain a better understanding of critical contextual components of TPACK. They will be able to use this information to develop more targeted professional development on educational technology that goes beyond basic user skills to focus on shifting teachers' attitudes and pedagogies. Further, this professional development could provide developmentally-appropriate models on how to effectively use tablet computers in the classroom as well as specific curricular-aligned digital content to ensure that teachers are using the best quality educational apps with their students.

Finally, policymakers will better understand the various contextual factors that influence early childhood educators' tablet computer integration. For example, while allocating funds for hardware, software, technology infrastructure is a necessary foundation for using technology in the classroom, factors such as teacher attitudes toward technology and teachers' understanding of how to effectively integrate the technology are needed as well. As such, future policy recommendations and professional development initiatives must take into account the interplay of student-, teacher-, and school-level factors on early childhood educators' technology use to ensure effective outcomes for teaching and learning.

References

American Academy of Pediatrics. (2013). Children, adolescents, and the media. *Pediatrics, 132*(5), 958–961. http://dx.doi.org/10.1542/peds.2013-2656.

American Academy of Pediatrics. (2015). *Growing up digital: Media research symposium*. Washington, DC: Author. Retrieved from https://aap.org/en-us/Documents/digital_media_symposium_proceedings.pdf.

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: advances in technological pedagogical content knowledge (TPCK). *Computers & Education, 52*(1), 154–168. http://dx.doi.org/10.1016/j.compedu.2008.07.006.

Beauchamp, G., Burden, K., & Abinett, E. (2015). teachers learning to use the iPad in Scotland and Wales: a new model of professional development. *Journal of Education for Teaching, 41*(2), 161–179. http://dx.doi.org/10.1080/02607478.2015.1013370.

Beschorner, B., & Hutchison, A. (2013). iPads as a literacy teaching tool in early childhood. *International Journal of Education in Mathematics, Science and Technology, 1*(1), 16–24.

Blackwell, C. K. (2013). Teacher practices with mobile technology: integrating iPads into the early childhood classroom. *Journal of Education Research, 7*(4), 1–25.

Blackwell, C. K. (2015). iPads in kindergarten: investigating the effect of tablet computers on student achievement. In *Paper presented at the International communication association, Puerto Rico, May 2015*.

Blackwell, C. K., Lauricella, A. R., & Wartella, E. (2014). Factors influencing digital technology use in early childhood education. *Computers & Education, 77*, 82–90. http://dx.doi.org/10.1016/j.compedu.2014.04.013.

Blackwell, C. K., Lauricella, A. R., Wartella, E., Robb, M., & Schomburg, R. (2013). Adoption and use of technology in early education: the interplay of extrinsic barriers and teacher attitudes. *Computers & Education, 69*, 310–319. http://dx.doi.org/10.1016/j.compedu.2013.07.024.

Blackwell, C. K., Wartella, E., Lauricella, A. R., & Robb, M. B. (2015). *Technology in the lives of educators and early childhood programs: Trends in access, use, and professional development from 2012–2014*. Evanston, IL: Center on Media and Human Development at Northwestern University.

Cahill, M., & McGill-Franzen, A. (2013). Selecting "app"ealing and "app"ropriate book apps for beginning readers. *The Reading Teacher, 67*(1), 30–39. http://dx.doi.org/10.1002/TRTR.1190.

Chai, C. S., Koh, J. H. L., & Tsai, C.-C. (2013). A review of technological pedagogical content knowledge. *Education Technology and Society, 16*(2), 31–51.

Cherner, T., Dix, J., & Lee, C. (2014). Cleaning up that mess: a framework for classifying educational apps. *Contemporary Issues in Technology and Teacher Education, 14*(2), 158–193.

Chou, C. C., Block, L., & Jesness, R. (2012). A case study of mobile learning pilot project in K- 12 schools. *Journal of Educational Technology Development and Exchange, 5*(2), 11–26.

Cordes, C., & Miller, E. (2000). *Fool's gold: A critical look at computers in childhood*. New York, NY: Alliance for Childhood. Retrieved from http://www.allianceforchildhood.net/projects/computers/computers_reports.htm.

Coughlan, S. (2014, December 3). *Tablet computers in '70% of schools.' BBC.com*. Retrieved from http://www.bbc.com/news/education-30216408.

Donohue, C. (2015). Technology and digital media as tools for teaching and learning in the digital age. In C. Donohue (Ed.), *Technology and digital media in the early years: Tools for teaching and learning* (pp. 21–35). York, NY: Routledge. Washington, DC: NAEYC.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2013). Removing obstacles to the pedagogical changes required by Jonassen's vision of authentic technology-enabled learning. *Computers & Education, 64*, 175–182. http://dx.doi.org/10.1016/j.compedu.2012.10.008.

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teachers beliefs and technology integration practices: a critical relationship. *Computers & Education, 59*, 423–435. http://dx.doi.org/10.1016/j.compedu.2012.02.001.

Eteokleous, N. (2008). Evaluating computer technology integration in a centralized school system. *Computers & Education, 51*(2), 669–681. http://dx.doi.org/10.1016/j.compedu.2007.07.004.

Falloon, G. (2013). Young students using iPads: app design and content influences their learning pathways. *Computers & Education, 68*, 505–521. http://dx.doi.org/10.1016/j.compedu.2013.06.006.

Fischer, M. J. (2015). *Personal computing in K-12 Q4 2014 market track report*. London, UK: Futuresource Consulting Ltd.

Fisch, S. M., & Truglio, R. T. (2001). *"G" is for growing: Thirty years of research on children and Sesame Street*. Mahwah, NJ: Lawrence Erlbaum Associates.

Geist, E. A. (2012). A qualitative examination of two-year-olds interaction with tablet based interactive technology. *Journal of Instructional Psychology, 39*(1), 26–35.

Gomez, F., Nussbaum, M., Weitz, J. F., Lopez, X., Mena, J., & Torres, A. (2013). Co-located single display collaborative learning for early childhood education. *Computer-Supported Collaborative Learning, 8*, 225–244. http://dx.doi.org/10.1007/s11412-013-9168-1.

Goodwin, K. (2012). *Use of tablet technology in the classroom*. Strathfield, NSW Australia: State of New South Wales Department of Education and Communities, Curriculum and Learning Innovation Centre. Retrieved from http://clic.det.nsw.edu.au/clic/documents/iPad_Evaluation_Sydney_Region_exec_summary.pdf.

Guernsey, L. (2007). *Screen time: How electronic media—from baby videos to educational software—affects your young child*. Philadelphia, PA: Basic Books.

Guernsey, L., Levine, M., Chiong, C., & Severns, M. (2012). *Pioneering literacy in the digital wild west: Empowering parents and educators*. Washington, DC: Campaign for Grade- Level Reading.

Henderson, S., & Yeow, J. (2012). iPad in education: a case study of iPad adoption and use in a primary school. In *In 45th Hawaii International conference on systems science (HICSS–45 2012) proceedings* (pp. 78–87). Maui, HI: IEEE Computer Society.

Highfield, K., & Goodwin, K. (2013). Apps for mathematics learning: a review of 'educational' apps from the iTunes App Store. In V. Steinle, L. Ball, & C. Bardini (Eds.), *Mathematics education: Yesterday, today and tomorrow. Proceedings of the 36th annual conference of the mathematics education research group of Australasia*. Melbourne, VIC: MERGA.

Hirsh-Pasek, K., Zosh, J. M., Michnick Golinkoff, R., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps: lessons from the science of learning. *Psychological Science in the Public Interest, 16*(1), 3–34. http://dx.doi.org/10.1177/1529100615569721.

International Society for Technology in Education (ISTE). (2007). *Profiles for technology (ICT) literacy students*. Washington, DC: Author. Retrieved from http://www.iste.org/standards/ISTE-standards/standards-for-students.

Janke, I., & Kumar, S. (2014). Digital didactical designs: teachers' integration of iPads for learning-centered processes. *Journal of Digital Learning in Teacher Education, 30*(3), 81–88.

Jennings, N. A., Hooker, S. D., & Linebarger, D. L. (2009). Educational television as mediated literacy environments for preschoolers. *Learning, Media, and Technology, 34*(2), 229–242. http://dx.doi.org/10.1080/17439880903141513.

Jones, L. (2007). *The student-centered classroom*. Cambridge, UK: Cambridge University Press.

Karaca, F., Can, G., & Yildirim, S. (2013). A path model for technology integration into elementary school settings in Turkey. *Computers & Education, 68*, 353–365. http://dx.doi.org/10.1016/j.compedu.2013.05.017.

Kelly, M. (2010). Technological Pedagogical content knowledge (TPACK): a content analysis of 2006-2009 print journal articles. In D. Gibson, & B. Dodge (Eds.), *Proceedings of society for information technology & teacher education International conference 2010* (pp. 3880–3888). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? *Journal of Education, 193*(3), 13–19.

Li, Q., & Ma, X. (2010). A meta-analysis of the effects of computer technology on school students' mathematics learning. *Educational Psychology Review, 22*(3), 215–243.

Lindahl, M., & Folkesson, A. (2012). Can we let computers change practice? Educators' interpretations of preschool tradition. *Computers in Human Behavior, 28*(5), 1728–1737. http://dx.doi.org/10.1016/j.chb.2012.04.012.

Louv, R. (2005/2008). *Last child in the woods: Saving our children from nature-deficit disorder*. New York, NY: Workman Publishing.

Lui, M., Scordino, R., Geurtz, R., Navarrete, C., Ko, Y., & Lim, M. (2014). A look at research on mobile learning in K-12 education from 2007 to the present. *Journal of Research on Technology in Education, 46*(4), 325–372.

McManis, L. D., & Gunnewig, S. B. (2012). Finding the education in educational technology with early learners. *Young Children, 67*(3), 14–24.

McManis, L. D., Simon, F., & Nemeth, K. (2012). *Voices from the field: 2012 national early childhood technology today survey*. Potomac, MD: Early Childhood Technology Collaborative. Retrieved from http://ecetech.net/.

Michael Cohen Group. (2011). *Young children, apps and iPad*. New York, NY: Michael Cohen Group. Retrieved from http://mcgrc.com/wp-content/uploads/2012/06/ipad-study-cover-page-report-mcg-info_new-online.pdf.

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: a framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

More, C. M., & Travers, J. C. (2013). What's app with that? Selecting educational apps for children with disabilities. *Young Exceptional Children, 16*(2), 15–32. http://dx.doi.org/10.1177/1096250612464763.

Mouza, C., & Barrett-Greenly, T. (2015). Bridging the app gap: an examination of a professional development initiative on mobile learning in urban schools. *Computers & Education, 88*. http://dx.doi.org/10.1016/j.compedu.2015.04.009.

Murray, O. T., & Olcese, N. R. (2011). Teaching and learning with iPads, ready or not? *TechTrends, 55*(6), 42–48.

National Association for the Education of Young Children. (2012). *Position statement: Technology and young children*. Washington, DC: Author. Retrieved from http://www.naeyc.org/content/technology-and-young-children.

National Institute for Literacy. (2008). *Developing early literacy: Report of the national early literacy panel*. Louisville, KY: National Center for Family Literacy.

Neuman, S. B., & Celano, D. C. (2012). Worlds apart: one city, two libraries, and ten years of watching inequality grow. *American Educator, 36*(3), 13–23.

Neumann, M. M., & Neumann, D. L. (2014). Touch screen tablets and emerging literacy. *Early Childhood Education Journal, 42*, 231–239. http://dx.doi.org/10.1007/s10643-013-0608-3.

Office of Head Start. (2012). *Head start E-rate technology plan*. Washington, DC: Author. Retrieved from http://eclkc.ohs.acf.hhs.gov/hslc/tta-system/operations/mang-sys/fiscal-mang/erate-toolkit/TechnologyPlanReferenceGuide.pdf.

Partnership for 21st Century Skills. (2009). *Framework for 21st century learning*. Washington, DC: Author. Retrieved from http://p21.org/storage/documents/P21_Framework.pdf.

Pasnik, S., & Llorente, C. (2013). *Preschool teachers can use a PBS KIDS transmedia curriculum supplement to support young children's mathematics learning: Results of a randomized controlled trial. A report to the CPB-PBS Ready to Learn initiative*. Waltham, MA: Menlo Park, CA: Education Development Center: SRI International.

Phillips, M. (2011). Parenting, time use, and disparities in academic outcomes. In G. J. Duncan, & R. J. Murnane (Eds.), *Whither opportunity? rising inequality, schools, and children's life chances* (pp. 207–228). New York, NY: Russell Sage Foundation.

Porras-Hernandez, L. H., & Salinas-Amescua, B. (2013). Strengthening TPACK: a broader notion of context and the use of teachers' narrative to reveal knowledge construction. *Journal of Computing Research, 48*(2), 223–244. http://dx.doi.org/10.2190/EC.48.2.f.

Rideout, V. (2013). *Zero to eight: Children's media use in America in 2013*. San Francisco, CA: Common Sense Media. Retrieved from https://www.commonsensemedia.org/research/zero-to-eight-childrens-media-use-in-america-2013.

Rosenberg, J. M., & Koehler, M. J. (2015). Context and technological pedagogical content knowledge (TPACK): a systematic review. *Journal of Research on Technology in Education, 47*(3), 186–210.

Ross, S. M., Morrison, G. R., & Lowther, D. L. (2010). Educational technology research past and present: balancing rigor and relevance to impact school learning. *Contemporary Educational Technology, 1*, 17–35.

Shuler, C. (2012). *iLearn II: An addendum: An analysis of the games category of Apple's app store.* New York, NY: The Joan Ganz Cooney Center. Retrieved from http://www.joanganzcooneycenter.org/wp-content/uploads/2012/11/jgcc_ilearn_games_addendum.pdf.

Shuler, C., Levine, Z., & Ree, J. (2012). *iLearn II: An analysis of the education category of Apple's app store.* New York, NY: The Joan Ganz Cooney Center. Retrieved from http://www.joanganzcooneycenter.org/wp-content/uploads/2012/01/ilearnii.pdf.

Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Siegle, D. (2013). iPads: intuitive technology for 21st-century students. *Gifted Child Today, 36*(2), 146–150.

Stipek, D., & Byler, P. (1997). Early childhood education teachers: do they practice what they preach? *Early Childhood Research Quarterly, 12*(3), 305–325.

Takeuchi, L. M., & Vaala, S. (2014). *Level up learning: A national survey on teaching with digital games.* New York, NY: The Joan Ganz Cooney Center at Sesame Workshop. Retrieved from http://www.joanganzcooneycenter.org/wp-content/uploads/2014/10/jgcc_leveluplearning_final.pdf.

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning: a second-order meta-analysis and validation study. *Review of Educational Research, 81*(1), 4–28. http://dx.doi.org/10.3102/0034654310393361.

Thorpe, K., Hansen, J., Danby, S., Davidson, C., Zaki, F. M., Grant, S., … Given, L. M. (2015). Teachers, teaching and digital technologies: reports from the early childhood classroom. *Early Childhood Research Quarterly, 32*, 174–182. http://dx.doi.org/10.1016/j.ecresq.2015.04.001.

Project Tomorrow. (2011). *The new 3E's of education: Enabled, engaged, empowered.* Irvine, CA: Author. Retrieved from http://www.tomorrow.org/speakup/pdfs/SU10_3EofEducation_Educators.pdf.

Tondeur, J., Hermans, R., van Braak, J., & Valcke, M. (2008). Exploring the link between teachers' educational belief profiles and different types of computer use in the classroom. *Computers in Human Behavior, 24*(4), 2541–2443.

Tootell, H., Plumb, M., Hadfield, C. D., & Dawson, L. (2013, January). Gestural interface technology in early childhood education: a framework for fully engaged communication. In *Paper presented at the 46th Hawaii International conference on system sciences (HICSS), Maui, HI.*

Turja, L., Endepohls-Olpe, M., & Chatoney, M. (2009). A conceptual framework for developing the curriculum and delivery of technology in early childhood. *International Journal of Technology and Design Education, 19*(4), 353–365. http://dx.doi.org/10.1007/s10798-009-9093-9.

Vaala, S., & Ly, A. (2014). *What's in store today: A snapshot of kids' language and literacy apps (Part 1).* New York, NY: The Joan Ganz Cooney Center. Retrieved from http://www.joanganzcooneycenter.org/2014/08/15/whats-in-store-today-a-snapshot-of-kids-language-and-literacy-apps-part-1/.

Viriyapong, R., & Harfield, A. (2013). Facing the challenges of the one-tablet-per-child policy in Thai primary school education. *Education, 4*(9).

Vockley, M., & Lang, J. (2011). *Deepening connections: Teachers increasingly rely on media and technology.* Washington, DC: PBS. Bethesda, MD: Grunwald Associates, LLC. http://www.grunwald.com/pdfs/PBS-GRUNWALD_2011_ANNUAL_ED_TECH_STUDY.pdf.

Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge: a review of the literature. *Journal of Computer Assisted Learning, 29*(2), 109–121. http://dx.doi.org/10.1111/j.1365-2729.2012.00487.x.

Warschauer, M., & Matuchniak, T. (2010). New technology and digital worlds: analyzing evidence of equity in access, use, and outcomes. *Review of Research in Education, 34*(1), 179–225. http://dx.doi.org/10.3102/0091732X09349791.

Wartella, E., Blackwell, C. K., Lauricella, A. R., & Robb, M. (2013). *Technology in the lives of teachers and classrooms: 2012 survey of teachers.* Latrobe, PA: The Fred Rogers Center. Retrieved from http://web5.soc.northwestern.edu/cmhd/wp-content/uploads/2013/10/FINAL-Fred_Rogers_Center_2013_Tech_Survey_Report.pdf.

Wartella, E., Rideout, V., Lauricella, A., & Connell, S. (2014). *Revised parenting in the age of digital technology: A national survey.* Evanston, IL: Center on Media and Human Development, School of Communication, Northwestern University. Retrieved from http://cmhd.northwestern.edu/wp-content/uploads/2015/06/ParentingAgeDigitalTechnology.REVISED.FINAL_.2014.pdf.

Wartella, E., & Robb, M. (2007). Young children, new media. *Journal of Children and Media, 1*(1), 35–44. http://dx.doi.org/10.1080/17482790601005207.

Yeh, Y.-F., Hwang, F.-K., & Hsu, Y.-S. (2015). Applying TPACK-P to a teacher education program. In Y.-S. Hsu (Ed.), *Development of science teachers' TPACK* (pp. 71–88). Singapore: Springer Science and Business Media. http://dx.doi.org/10.1007/978-981-287-441-2_5.