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ORIGINAL PAPER

Incorporating Technology into Instruction in Early Childhood Classrooms: a Systematic Review

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Abstract

Objectives The purpose of this review is to describe the variety and effectiveness of instructional technologies used in the early childhood setting.

Methods A systematic review of three databases was completed, and studies were reviewed by two independent coders to determine if they met inclusion criteria. Studies were excluded from this review if (a) the technology was used to train teachers and was not directly used with early childhood students, (b) participants were all enrolled in 2nd grade or higher, (c) the setting was not an early childhood education setting, or (d) studies were descriptive in nature or utilized a survey methodology. Data were extracted from each article related to participant characteristics, setting characteristics, research design, technology type, and dependent variables.

Results Thirty-five studies met criteria were included in this review. A wide range of technologies were used to provide or facilitate instruction on (a) academics, (b) social and communication skills, and (c) cognitive skills. Academic outcomes targeted in Head Start preschools were the most common across studies. The results ranged from no effect to highly effective.

Conclusions The findings from the included studies varied widely in their outcomes from reporting no difference between traditional instruction and technology-aided instruction to reporting significant difference between groups or reporting a functional relation between the technology-based intervention and the target behavior or skill. Studies that included students identified with neurodevelopmental disorders demonstrated a positive impact in the outcomes of students who experience an intervention that included technology-aided instruction. Future research is needed to identify critical components of effective technology-based interventions in early childhood educational settings.

Keywords Technology · Technology-aided instruction · Early childhood education · Preschool settings

Decades of research indicate that access to high-quality early learning environments is predictive of later success (Guralnick, 1991; Ramey & Ramey, 1994; White, 1985). High-quality early childhood education (i.e., education for children ages 3–8) is associated with superior academic achievement throughout the lifespan. In fact, a meta-analysis of studies that examined the longitudinal effects of early childhood education reported moderate effect sizes of preschool programs on academic skills all the way through eighth grade (i.e., $d = 0.30$), with similar effects in social communication ($d = 0.27$) that persisted into high school ($d = 0.33$; Nelson et al., 2003). A more recent study found that participants of a rigorous preschool program following the Montessori model showed minimized differences between children at program exit who had been behind at program entry, indicating that high-quality preschool may be sufficient for children at risk to catch up to peers (Lillard et al., 2017). On a range of measures, the benefit of high-quality early childhood education environments has remained evident.

Recently, high-tech elements have become part of the preschool learning environment (Northrop & Killeen, 2013; Reeves et al., 2017; Rodgers et al., 2016). In the past, technology has been a controversial addition to early childhood settings, with parent and educator concerns about long-term screen time effects governing policy on the presence of technology in classrooms (Blackwell et al., 2013; Jeong & Kim, 2017; Parette et al., 2010). A major change came in 2012, when the National Association for the Education of young Children (NAEYC) and the Fred Rodgers Center published a joint position statement

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on the use of technology in early childhood classrooms and instruction (NAEYC & Fred Rodgers Center, 2012). This statement signaled a shift in thinking about how technology could be incorporated into high-quality early childhood programs and paired with an increase in available technology, which allowed for a rapid increase of technology in quality-rated classrooms. In a 2018 study of early childhood educators, 89% of respondents reported having Internet access in their classroom, 81% had a desktop computer, 71% tablets, and 30% an interactive whiteboard (Pila et al., 2019). These results indicate as much as a threefold increase in student access to technology in the last 6 years. The results of the survey further indicated that early childhood educators had noticed an increase in access to technology in their classroom in the last 3 years and that their rating of the acceptability of the technology remained consistently neutral to high (Pila et al., 2019).

A diverse array of technologies can be found in today's early childhood programs. Over 90% of respondents to a survey on technology in preschool reported using some form of technology in the preschool classroom (Pila et al., 2019). The technology used in early childhood classrooms ranges all the way from technology specific to classroom settings, like digital whiteboards (30%), to more ubiquitous technology like Internet-enabled computers (89%) and televisions (63%) (Pila et al., 2019). Despite the broadening role of technology in early childhood, there are limited resources available to ensure the technology is being used to its optimal benefit. In a qualitative analysis of teacher perceptions of ease of use and observations uptake of instructional technology in preschool classrooms in Shanghai, China, Dong (2016) found that while teachers are observed to be using more technology in their classrooms, they do not always feel they can keep pace with ever-changing technology, a finding supported by more than one survey of teachers about technology use at school (e.g., Mertala, 2019; Yildiz Durak, 2021).

In educational settings serving individuals with neurodevelopmental disabilities across the lifespan, technology-based interventions are more established. For instance, video modeling is considered an evidence-based practice for individuals with autism spectrum disorders (ASD), and computer-based instruction has shown good effect for addressing learning disabilities (Park et al., 2019; Zavaraki et al., 2019). Evidence-based practices for improving communication, functional life skills, and addressing challenging behavior have all been modified to contain technology and continued to be effective (e.g., LeJeune et al., 2021; Light et al., 2019; Schmidt & Glaser, 2021). Despite their evident effectiveness, technology-based interventions have been differentially applied to individuals with disabilities outside of the classroom setting, especially in the younger ages (Lancioni et al., 2019; Lynch et al., 2022). The utility of technology in early childhood settings to improve outcomes for individuals with and without neurodevelopmental disabilities needs to be assessed.

There is increased capacity to deliver evidenced-based intervention and teaching strategies by capitalizing on technology, as evidenced by consistent innovations in both technology and education. These innovations are promising, but so far documented by mostly exploratory or descriptive research (see Su et al., 2022, for examples). An analysis of experimental research to measure the effectiveness of technological innovations in the early childhood education setting is warranted. Of particular interest is the adaptation of typical early childhood educational practices (i.e., developmentally appropriate practice; Copple et al., 2013) to include technology. For example, circle-times or morning meetings transformed by a movement video on the whiteboard, or an investigation or space enriched by the NASA website. There is some evidence to suggest that technological advances in the classroom can have a positive effect in academic or pre-academic gains, such as early literacy skills (Meadan et al., 2008; Parette et al., 2009). Despite the potential promise of adaptations of current practices to include technology, there is little guidance on how to effectively implement.

Technology in early childhood, as in the world at large, is rapidly changing. Previous reviews have examined specific pieces of technology such as tablets (Couse & Chen, 2010; Neumann, 2018; Neumann & Neumann, 2014) and literacy aides (Jamshidifarsani et al., 2019) and found mixed results of these interventions. Previous reviews have also aimed to describe the effects of technology on instruction more generally, as well as perceptions of technology in early childhood curricula (Wang et al., 2010; Sarker et al., 2019). Neither of these previous reviews partitioned out the efficacy for individuals with developmental disabilities. Finally, technology as a support for individuals with developmental disabilities is robust in the literature (e.g., Sun et al., 2022; Ramdoss et al., 2011). While the results of these reviews demonstrate potential for these technologies, they report results for a range of settings and ages. To our knowledge, previous reviews of the literature have not addressed classroom technology in early childhood related to children with and without disabilities. The current review aims to extend the previously available reviews and address the following research questions: (a) How is technology used in instruction in early childhood educational settings? and (b) What is the effect of technologies used in instruction in early childhood settings for students with and without disabilities?

Method

Procedure

Systematic searches were completed using three electronic databases: Education Resources Information Center (ERIC), Academic Search Premier, and PsycINFO. In all databases, the following search term combinations were entered ("technology" or "smartboard" or "whiteboard" or "tablet" or "digital") and ("early childhood" or "preschool" or "early learning") and ("intervention" or "curriculum" or "instruction") in the keywords field. Only peer-reviewed articles from 2013 to 2021 were included in this systematic review.

Across all three databases, 45,455 results were returned. With duplicates removed, there were 1468 abstracts for review. The abstracts of the returned studies were reviewed, and those studies using an experimental or quasi-experimental design were retained. All searches by the second author took place in May 2020. Reliability searches completed by the fourth author took place in June 2020. Reliability coding and discussion among coauthors took place in August 2020. Following reviewer feedback, the search was extended in April of 2022 to include the years 2020–2021. A total of 140 abstracts were selected for potential inclusion before examination with the inclusion criterion. Initial search procedures were conducted by the fourth author for years 2013–2020 and by the third author for years 2020–2021. For a visual of the search procedures, please see Fig. 1.

Reliability

Reliability procedures on inclusion/exclusion were conducted by the second author. The written search procedures were replicated by the fourth author. A 100% agreement was reached between the second and fourth author on inclusion and exclusion decisions following a retraining session to remediate a misunderstanding. This procedure was replicated between the second and third authors for the additional year with 98% agreement. The article with a disagreement was removed. For the years 2020–2021, there was one disagreement, which was discussed, and an agreement was reached. Reliability on data extraction was completed for 30% of included studies. Reliability on data extraction was 100%.

In order to be included in this review, each study needed to meet a set of inclusion criteria. Requirements for inclusion were (a) publication in an English language peer-reviewed journal between the years 2013 and 2021; (b) utilized an

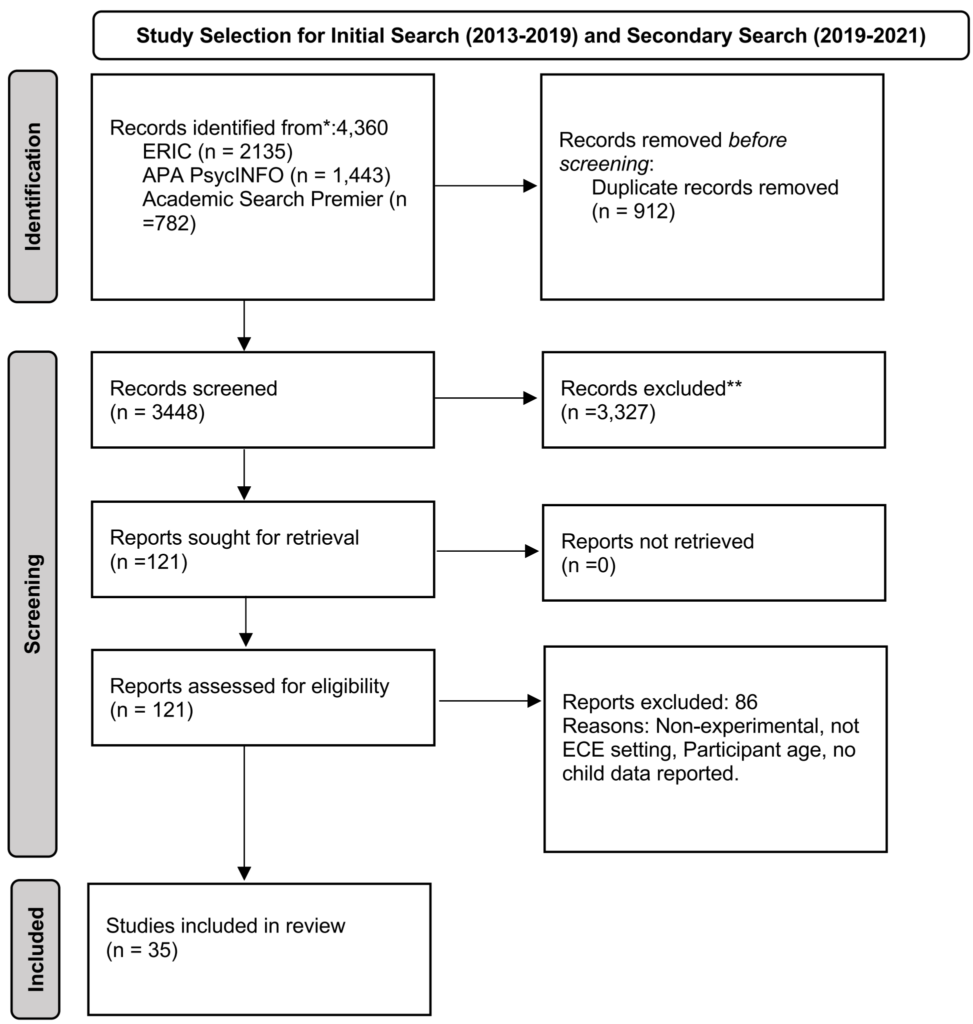

Fig. 1 Article search and selection procedure

experimental or quasi-experimental design; (c) the intervention took place in a pre-K, kindergarten, or 1st grade educational setting; and (d) included technology as a part of the independent variable. Studies were excluded from this review if (a) the technology was used to train teachers and was not directly used with early childhood students (e.g., Aldimir, 2016); (b) participants were all enrolled in 2nd grade or higher (e.g., Gardner et al., 2015); (c) the setting was not an early childhood education setting (e.g., clinical setting; Gilliver et al., 2016); and (d) studies were descriptive or exploratory in nature or utilized a survey methodology (e.g., Danby et al., 2016).

Data Analyses

Data were initially extracted by the first and third authors using a spreadsheet created for this review. Data were reported on the following variables: (a) participants (number, age, gender, race/ethnicity, disability); (b) setting; (c) research design; (d) independent variable (technology used); (e) dependent variables; and (f) results. The dependent variables for the included studies were categorized as (a) academic and cognitive skills (e.g., general knowledge, early literacy skills, early mathematics skills, vocabulary skills, cognitive skills); (b) social communication skills(e.g., requesting, commenting, social exchanges); (c) social-emotional skills (e.g., social-emotional learning, behavior); (d) engagement; (e) programming skills; (f) motor skills; and (g) attitudes and perceptions towards the technology and/or intervention.

Results

Thirty-five studies met criteria and were included in this review of technology use in early childhood settings. Data were extracted from each article related to participant characteristics, setting characteristics, research design, technology type, and dependent variables (see Tables 1 and 2).

Participant Characteristics

Across the 35 included studies, there were 4720 participants with sample sizes ranging from 3 to 766 participants. Ages of participants ranged from 2 to 7 years old. In several studies, only a mean age was reported (Desoete & Praet, 2013; Hsiao & Chen, 2016; Lee & Tu, 2016; Maureen et al., 2018) while one study reported a grade range (i.e., K-2nd grade; Kim et al., 2019). Participant gender was reported in 29 of the included studies (83%). For the 29 studies that reported participant gender, 2183 participants were male, and 2176 were female. Race and/or ethnicity were reported in only 10 of the 35 studies (28%). For the ten studies that included this data, 475 participants identified as Caucasian, 790 identified as Hispanic, 230 identified as African American, 36 identified as Asian, 133 identified as multi-racial, and 127 as Other. Fourteen of the included studies (40%) included information on the disability status of their participants. Four studies reported participants with autism spectrum disorder (Cardon et al., 2019; Dueñas et al., 2021; Jung & Sainato, 2015; Pellegrino et al., 2020); three studies reported participants with intellectual disability or developmental disabilities (Boyle et al., 2021; Chai, 2017; Taylor, 2018); two studies reported participants with specific learning disability and speech language impairment or learning disabilities in general (Amorim et al., 2020; Musti-Rao et al., 2015); and four studies reported participants as having an IEP or an unspecified qualification for special education (Kim et al., 2019; Lee & Tu, 2016; Sullivan & Bers, 2018; Wilkes et al., 2020). One study reported including students "at risk" for mathematics difficulty (Desoete & Praet, 2013). Finally, five studies reported that they did not include students with disabilities (Dennis et al., 2016; Maureen et al., 2018; McCoy et al., 2017; Oades-Sese et al., 2021; Simsek & Isikoglu Erdogan, 2021).

Setting Characteristics

In order to be included in this review, the studies needed to take place in an early childhood education setting (see Table 1). Thirty-one studies (89%) took place in a Head Start, preschool, or early elementary school classroom. Three studies (9%) took place in a 1:1 setting within a school (e.g., table between classrooms or empty room; Chai, 2017; Dennis et al., 2016; Taylor, 2018), and one study (3%) took place as part of a summer reading program (Kim et al., 2019).

Research Design

The included studies utilized a variety of experimental and quasi-experimental designs to evaluate the impact of the technology on targeted skills in early childhood education settings (see Table 2). Eleven (31%) of the included studies were randomized control trials, ten (29%) utilized a single-case design, nine (26%) utilized quasi-experimental designs, three utilized a mixed methods design, one utilized a SMART design, and one utilized a pre-post (no control group) design.

Technology Type

A variety of technologies were used in the studies including tablets (40%), computers/computer games (17%), robots (9%), projection devices (6%), video models (6%), whiteboards (3%), and motion sensor 3D camera scanner (ASUS

Table 1 Participant and setting characteristics

Reference	Participant characteristics					Setting
	N	Age	Gender	Race/ethnicity	Disability	
Aunio and Mononen (2018)	22	4–6 years	7 male 15 female	Not reported	Not reported	Preschool classrooms
Cardon et al. (2019)	6	39–52 months	7 male 1 female	Not reported	ASD	Preschool classroom
Chai (2017)	3	4–5 years	2 male 1 female	2 Caucasian 1 Hispanic	Developmental delay	Empty classroom
Dennis et al. (2016)	5	4–5 years	2 male 3 female	Not reported	None	Table between classrooms
Desoete and Praet (2013)	139	Mean age 5.8 years	69 male 70 female	Not reported	40 students at risk for mathematical difficulties	Classroom
Furman et al. (2019)	47	5–6 years	23 male 24 female	Not reported	Not reported	Preschool classrooms
Hsiao and Chen (2016)	105	Mean age 5.5 years	56 male 49 female	Not reported	Not reported	Preschool classroom
Jung and Sainato (2015)	9	5–6 years	Not reported	Not reported	ASD (3)	Kindergarten classrooms
Kim et al. (2019)	273	K-2nd grade	123 male 150 female	Not reported	8.4% with IEP	Summer reading program
Korat et al. (2017)	78	5–6 years	Not reported	Not reported	Not reported	Kindergarten classroom
Lee and Tu (2016)	161	Mean age 3.5 years	90 males 71 females	Not reported	37 ELLs 18 special education	Preschool classrooms
Martín et al. (2017)	64	3–5 years	Not reported	Not reported	Not reported	Preschool classroom
Maureen et al. (2018)	37	Mean age 5.39 years	20 male 25 female	Not reported	None	Public preschool classrooms
Maureen et al. (2020)	62	5–6 years	32 male 30 female	Not reported	Not reported	Preschool classroom
McCoy et al. (2017)	3	3–5 years	2 male 1 female	Not reported	None	Preschool classroom
Muñoz-Repiso and Caballero-González (2019)	131	3–6 years	70 male 61 female	Not reported	Not reported	Classroom
Musti-Rao et al. (2015)	3	6 years	2 male 1 female	Hispanic	Specific learning disability (1) Speech language impairment (1)	First grade classrooms
Papadakis et al. (2018)	365	4–5 years	177 male 188 female	Not reported	Not reported	Kindergarten classrooms
Schacter and Jo (2017)	433	4 years	219 male 214 female	244 Caucasian 111 Hispanic 60 African American 5 Asian 1 Multiracial	Not reported	Private preschool classrooms
Sullivan and Bers (2018)	105	5–7 years	Not reported	Not reported	25.7% with disability	Public school classrooms
Taylor et al. (2018)	3	4–7 years	1 male 2 female	Caucasian	Down syndrome (ID)	1:1 setting at home or school
Vatalaro et al. (2017)	63	3–5 years	33 male 30 female	4 African American 49 Hispanic 4 Multiracial 6 Other	Not reported	Head Start classrooms

Table 2 Research design, independent variables and dependent variables

	Research design	Technology	Dependent variable(s)	Outcomes
Aunio and Mononen (2018)	RCT	Computer game	• Early mathematics skills • Non-verbal reasoning	Both groups improved from pre-test to post-test, no significant between groups differences
Cardon et al. (2019)	Single-case design	Video models	• Social skills • Transition skills	Minimal effects in reversal design, authors report increase in attention to videos following peer-mediated intervention
Chai (2017)	Single-case design	Tablet (iPad)	• Early literacy skills (target phonemes)	Increased correct responses across phonemes for all participants
Dennis et al. (2016)	Single-case design	Tablet	• Vocabulary skills	Little separation between teacher delivered and iPad delivered instruction for most participants
Desoete and Praet (2013)	RCT	Computer games	• Early mathematics skills	Authors report increased effectiveness of ICT-delivered intervention on early mathematical skills in pre-post design
Furman et al. (2019)	Quasi-experimental	Tablet	• Academic skills (science)	Authors report improvements in science outcomes for students who did and did not receive tablet-mediated intervention
Hsiao and Chen (2016)	Quasi-experimental	Motion sensor 3D camera scanner (ASUS Xtion Pro)	• General knowledge • Motor skills	Authors report better learning performance for students in the game-based learning group
Jung and Sainato (2015)	Single-case design	Video models	• Engagement • Social skills • Challenging behavior	Increased non-verbal and verbal engagement across participants in a multiple baseline design
Kim et al. (2019)	SMART	Tablet	• Vocabulary skills (science) • Listening comprehension	Authors report that non-responders to initial intervention improved following gamification of app and parent prompts for participation
Korat et al. (2017)	RCT	E-book	• Early literacy skills	Authors report increase in novel word learning for children with access to an E-book across conditions and learning targets
Lee and Tu (2016)	Pre-post (no control group)	Tablet (iPad)	• Academic skills (general) • Cognitive skills	Authors report all participants increased their science learning abilities following the tablet intervention, but the group with the largest gain was the English language learners
Martín et al. (2017)	RCT	Tablets and interactive whiteboards	• Academic skills (general) • Attitudes and interactions	Authors report that students who were in the technology-based conditions demonstrated more motivation and better results than students in the paper card condition
Maureen et al. (2018)	Quasi-experimental	Projection device	• Early literacy skills	Authors report that the digital literacy intervention improved child literacy skills above the gains made by students in the typical literacy intervention
Maureen et al. (2020)	RCT	Projection device	• Early literacy skills • Cognitive skills • Social-emotional skills	Authors report structured storytelling via play-based activities or digital storytelling activities increased child literacy skill

Table 2 (continued)

	Research design	Technology	Dependent variable(s)	Outcomes
McCoy et al. (2017)	Single-case design	Tablet (iPad)	• Academic engagement • Off-task behaviors	Small effect of tablet-mediated intervention on increased engagement and decreased off-task behavior for both photo and video presentation in multiple baseline
Muñoz-Repiso and Caballero-González (2019)	Quasi-experimental	Robot	• Computational thinking • Programming skills	Authors report that children in the robotics program demonstrated larger gains in computational thinking than students in the control group
Musti-Rao et al. (2015)	Single-case design	Tablet (iPad)	• Early literacy skills • Academic engagement	Small increase in correct words per minute across participants in a multiple baseline design
Papadakis et al. (2018)	RCT	Computers and tablets	• Early mathematics skills	Authors report students in both the computer and tablet conditions improved relative to the control condition
Schacter and Jo (2017)	RCT	Tablet	• Early mathematics skills	Authors report increased math achievement for students in the iPad app condition
Sullivan and Bers (2018)	Mixed methods	Robot	• Programming skills • Attitudes towards programming	Authors report students' interest in robotics and technology and engineering in general increased
Taylor et al. (2018)	Single-case design	Robot	• Programming skills	Increase in correct responses across participants in a changing criterion design
Vatalaro et al. (2017)	Quasi-experimental	Tablet	• Vocabulary skills	Authors report increased performance on the PPVT-4 following intervention with the iPad app

Xtion Pro; 3%). Several studies utilized more than one type of technology (Martín et al., 2017; Papadakis et al., 2018). The intervention protocols varied widely across the included studies including teacher-directed or independent student interaction with iPad apps or computer games (Aunio & Mononen, 2018; Chai, 2017; Dennis et al., 2016; Desoete & Praet, 2013; Hsiao & Chen, 2016; Lee & Tu, 2016; Musti-Rao et al., 2015; Papadakis et al., 2018; Schacter & Jo, 2017; Vatalaro et al., 2017), explicit instruction protocols (Taylor, 2018), video modeling protocols (Cardon et al., 2019; Jung & Sainato, 2015), e-books with embedded vocabulary supports (Korat et al., 2017), and digital storytelling (Maureen et al., 2018; Maureen et al., 2020).

Independent Variables

A majority (21, 60%) of the included studies had independent variables that were the same as the technology used, for example, an instructional video game or a tablet app. The technology used was only coded as the independent variable if no other information was given about intervention components. The remaining 14 studies (40%) included the following: social communication intervention (2, 14%), vocabulary instruction (2, 14%), math instruction (2, 14%), peer mediated instruction (2, 14%), inquiry-based science learning (2, 14%), leveled literacy intervention (1, 7%), project-based learning (1, 7%), story-based learning (2, 14%), and flashcards (2, 14%).

Dependent Variables

Several skill areas were addressed in the 35 included studies: academic and cognitive skills (e.g., general knowledge, early literacy skills, early mathematics skills, vocabulary skills, auditory processing, logic, and reasoning), social communication skills, social-emotional skills, engagement, programming skills, and motor skills. Additionally, several studies measured students' attitudes and perceptions towards the technology and/or intervention (Martín et al., 2017; Sullivan & Bers, 2018). Academic and cognitive skills were targeted in 28 studies (80%), while social communication skills were only addressed in three studies (9%). Academic engagement and programming skills were each addressed in three studies (9%), while motor skill and social-emotional skills were addressed in only one study (3%).

Outcomes

The included studies reported results that ranged from no effect to significant effects of the technology-based intervention. For studies that compared a technology intervention to a traditional intervention, seven reported improvements across both groups from pre-test to posttest with no significant difference between the group who had access to the technology-based intervention and the control group (Aunio & Mononen, 2018; Furman et al. 2019; Oades-Sese et al., 2021; Outhwaite et al., 2020; Pan et al., 2021; Redondo et al., 2020; Simsek & Isikoglu Erdogan, 2021), while thirteen studies reported significant differences between technology and control groups with the group who had access to the technology-based intervention outperforming the control group on outcome measure (Amorim et al., 2020; Desoete & Praet, 2013; Hsiao & Chen, 2016; Korat et al., 2017; Martín et al., 2017; Maureen et al., 2018; Maureen et al., 2020; Muñoz-Repiso & Caballero-González, 2019; Papadakis et al., 2018; Schacter & Jo, 2017; Sullivan & Bers, 2018; Tang, 2020; Vatalaro et al., 2017; Wilkes et al., 2020). One study showed varying results across control and intervention groups, meaning that one group performed higher on certain skills than the other and vice-versa (Elimelech & Aram, 2020). For the included studies that employed a single-case research design, the results were mixed as well with most studies reporting an increase in target academic skills (Boyle et al., 2021; Chai, 2017; Musti-Rao et al., 2015), programming skills (Taylor, 2018), and engagement (McCoy et al., 2017) or social skills (Dueñas et al., 2021; Jung & Sainato, 2015; Pellegrino et al., 2020), while a few reported no clear, functional relation between the intervention and dependent variable (Cardon et al., 2019; Dennis et al., 2016).

Discussion

Results of this review indicate a large range of interventions, devices, and intervention targets for the inclusion of technology in early childhood settings. Results clearly indicate robust use of technology in the education of young children with and without disabilities across the included years. In the 35 included studies, there were interventions across both academic and social communication-dependent variables, although most studies targeted academic skills, mostly literacy. Tablets were by far the most used technology in the classroom, with a variety of other technologies (e.g., computers, digital whiteboards, augmentative reality technology) represented as well. Across the included studies, there were mixed effects of technology-based interventions. While some studies reported robust and differential effects of technology-mediated intervention compared to traditional "paper and pencil" intervention, many studies showed no substantial difference between business as usual and instruction or intervention mediated by technology.

As the availability of technology increases in the typical early childhood environment, technology is included in intervention incidentally more frequently, rather than the purpose of the study to investigate the role of technology. For example, research on group instruction may capture the use of a digital whiteboard without the goal of the study being to evaluate the efficacy of the use of a digital whiteboard. Likewise, evaluations of functional communication training that utilize a speech-generating application on an iPad may not evaluate the effectiveness of the iPad but rather the teaching procedure for increasing functional communication. Given the ubiquity of technology in a typical preschooler's daily world, it is possible the literature presented in this review did not capture the scope of technology literature for children in early childhood settings. Particularly, technology is frequently used in interventions for children with disabilities outside of the classroom context, which would not be captured by this review. Studies included in this review and captured via the search procedures used varied as whether they delivered an intervention that could only be delivered via technology (e.g., a math computer game) or the differential effectiveness of an intervention delivered through a technological mode or an analog mode (e.g., early literacy interventions). Future reviews and research may consider partitioning out these two separate types of studies to better evaluate the effectiveness of technology as an intervention agent.

Notably, only eight studies included in this review reported including students with disabilities or targeting special education classrooms (e.g., Cardon et al., 2019; Chai, 2017; Jung & Sainato, 2015; Kim et al., 2019; Lee & Tu, 2016; Musti-Rao et al., 2015; Sullivan & Bers, 2018; Taylor, 2018). Technology such as iPads, speech generating devices, and video modeling technology have a likely larger footprint in special education settings; however, many of these studies may not have been captured by this review. In several of the included studies, technology-based instruction or intervention served as a bridge for students who require additional supports. Instructional technology to adapt general education content to meet the needs of children with disabilities is supported by the studies included in this review. Attitudes towards technology in early childhood may also differ in special education versus general education settings. A differential analysis of the utility and frequency of use of technological interventions in early childhood general and special education may illuminate some potential avenues to improve inclusion.

Within the included interventions, there were a range of intervention targets. Despite only including intervention studies that took place in early childhood settings, the large majority of included studies were academic focused. There was a relative lack of technology-mediated studies focused on social communication interventions, play, or adaptive skills, all of which may benefit from technology (e.g., Saleh et al., 2021; Schmidt & Glaser, 2021). In a systematic review specific to ASD, authors found potential merits of using technology to support social communication deficits inherent to the ASD diagnosis (Pham et al., 2019). As more children have ready access to tablets, smart phones, and gaming platforms at home from a young age, interventions to support social communication capitalizing on the reinforcing nature of these technologies may be especially useful. Gamification, which was only minimally represented in this review, may be a compelling way to include technology in typical instruction of adaptive skills in early childhood settings, as video modeling has been shown to be effective.

Finally, the landscape of technology in education, while always rapidly evolving, has had to evolve significantly due to the COVID-19 pandemic. This trend is emphasized within this review by the exponential growth of included studies across the search years. With many if not all learning opportunities moving online even for very young children, technology may not have been optional in early childhood educational settings in the last year as it was in the studies included in this review. New methods to move instruction of very young children to an online platform need analysis and will likely change the perceived effectiveness of many of these interventions as well as potentially the early childhood philosophy of technology use in the early years. As more educational opportunities are moved online, technology-based interventions for young children will likely become more common, and teacher perceptions of technology may change.

Limitations and Future Research

This review, while systematic, did have several limitations. Primarily, we constrained the reported results to only early childhood educational settings. Studies conducted in clinical settings or with parents at home were not included and may have captured more or different technology use. Our definition of technology was also broad by design in order to best capture the complete footprint of technology in interventions in academic settings for young children. A more focused review, however, might have allowed for more analysis of certain technologies likely to be considered for adaptation for use in early childhood settings, for example, digital whiteboards. Additionally, both experimental and quasi-experimental studies were included in this review in order to provide a more complete picture of the existing research in this emerging area. When interpreting the results, care should be taken to ensure conclusions from more rigorous experimental studies are not overshadowed by contradictory findings from less rigorous quasi-experimental studies. We would also like to highlight the search terms used as a limitation of this study. Potentially the addition of more search terms could have broadened the number of studies returned for examination. Additionally, an ancestral search of included studies was not included in this paper which serves as another limitation to the findings of this review. Finally, due to the diversity of research methods and analyses, we were unable to present effect sizes or mathematically evaluate the role of technology in early childhood settings. Statistical analyses of the effectiveness of these interventions could have led to more effective recommendations for practice.

We identified several areas for future research and practice. Future research should further explore the utility of technology in early childhood settings for intervention targets outside academic areas, as most of the included studies addressed academic targets. Social skill interventions facilitated by technology and embedded into the larger classroom curriculum, for example, may benefit young children with ASD and other developmental disabilities at school (Heinrich et al., 2016; Simpson et al., 2004). Additionally, all available guidelines for the technology use of young children indicates that the quality of the technology and the degree to which technology use is mediated by adult attention is critical to determine whether technology is a value-added or a potentially harmful factor. Many of these studies did not clearly describe dosage and adult involvement in technology use. In addition, very little information is given in many of these studies as to whether the teachers were trained or how well they implemented the technology. Further, many of the included interventions were packaged interventions including a computer-based or tablet-based component. Future analyses should partition out the use of the technology from a well-planned delivery of the intervention in order to determine whether technology-mediated intervention is in fact more valuable. Social validity measures should also be carefully considered in future research, as preference may play a large role in the increased effectiveness of some of the technology-mediated studies.

Evidence from this review gives suggestions for practice that mirror those of professional organizations such as NAEYC (Copple et al., 2013). It appears that technology can improve outcomes for students on a range of skills, but the ability of interventions utilizing technology to improve the effectiveness of evidence-based practices likely depends upon a range of factors including dosage, student preference, teacher participation, teacher familiarity with technology, and the culture of the classroom towards technology. Interventions included in this review that demonstrated higher effectiveness of technology-based intervention than analog interventions likely improved one or more of those factors leading to increased engagement, greater dosage or ease of use of the intervention, or more efficient intervention delivery. Early childhood educational environments should include technology in instruction intentionally and moderated by skilled teachers who can monitor learning and provide meaningful connections. Training teachers effectively in how to teach using technology is critical to effective interventions.

Declarations

Competing Interests The authors declare no competing interests.

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*Indicates studies included in the review

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