


# The Use of Digital Technologies to Develop Young Children's Language and Literacy Skills: A Systematic Review

SAGE Open  
 January-March 2024: 1–18  
 © The Author(s) 2024  
 DOI: 10.1177/21582440241230850  
[journals.sagepub.com/home/sgo](https://journals.sagepub.com/home/sgo)  


Sylvia Liu<sup>1</sup> , Barry Lee Reynolds<sup>1,2</sup> , Nathan Thomas<sup>3</sup>,  
 and Ali Soyoo<sup>1,4</sup> 

## Abstract

This review was conducted to explore the use of digital technologies with young children in early childhood language and literacy education. It centers on peer-reviewed empirical journal articles published during the past two decades. An initial sample of refereed journal articles ( $N = 631$ ) was compiled from systematically searching the Web of Science Core Collection databases. Following strict inclusion and exclusion criteria, 89 articles were included in the review. Five major dimensions of the selected studies were coded: demographic information, setting, digital technology used, research designs, and research findings. All of the articles selected for inclusion were systematically mapped to provide a valuable resource for researchers in this area. The main findings of the review were categorized and are reported in five subsections: print knowledge, alphabet knowledge, phonological awareness, early vocabulary knowledge, and narrative skills. Each subsection is framed with practical implications gleaned from the empirical studies.

## Keywords

e-learning, young children, early childhood language and literacy education

## Introduction

Digital technologies are widely used in early childhood education (ECE) in various forms of e-learning to support the development of young children's emergent literacy skills (Jack & Higgins, 2019; Soyoo et al., 2024). E-learning is defined as a modern learning approach that includes various teaching methods and learning designs with the support of digital technology (Nikolopoulou, 2014; Noesgaard & Ørngreen, 2015). The main characteristic of e-learning is that "it overcomes time and spatial restrictions, since learners can attend the course wherever they are, assuming they have adequate equipment, such as a computer connected to the Internet" (Kazanidis et al., 2014, p. 149). Before the year 2011, most young children exposed to e-learning were instructed to sit properly in front of a desktop computer and hold a mouse to interact with educational software (Rideout et al., 2003). However, actions executed with a mouse require a high level of fine motor skills (Shanis & Hedge, 2003). Nevertheless, previous research showed that young children's early interactions with desktop computers through educational software, games, and e-books positively

influenced their language development (Segers & Verhoeven, 2005; Sylla et al., 2016; Van Scoter, 2008).

In contrast to desktop computers, contemporary mobile devices (e.g., touch screen tablets and smart phones) provide young children a simple and easy tactile interface with finger-based operating features (Nacher et al., 2015). The options of touching, pointing, scribbling, and swiping have allowed young children to become immersed in the digital world much earlier than previous generations (Hoffman & Paciga, 2014; Price et al., 2015). Today, young children do not have to wait for their fine motor skills to reach certain milestones to access e-learning. They can place a tablet on their lap

<sup>1</sup>Faculty of Education, University of Macau, Taipa, Macao SAR

<sup>2</sup>Centre for Cognitive and Brain Sciences, University of Macau, Taipa, Macao SAR

<sup>3</sup>Centre for Applied Linguistics, UCL (University College London), UK

<sup>4</sup>Monash University, Melbourne, VIC, Australia

## Corresponding Author:

Barry Lee Reynolds, Faculty of Education, University of Macau, Room 1014, Faculty of Education (E33), Avenida da Universidade, Taipa, Macao SAR.  
 Email: [BarryReynolds@um.edu.mo](mailto:BarryReynolds@um.edu.mo)



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and interact with the screen through touching and tapping with their fingertips. Besides, young children can easily orient themselves to the screens of mobile devices that can be set to auto-rotate (Neumann, 2016).

Since the use of mobile devices has become ubiquitous in young children's lives, it is understandable that caregivers and teachers would contemplate how digital technologies can be better utilized for early childhood (EC) language and literacy education. In ECE, teachers and parents support language and literacy development by using a variety of simple topics (e.g., colors, numbers, and animals) through face-to-face activities such as chanting, singing songs, and reading storybooks (Office of English Language Acquisition, 2020). Contemporary digital technologies, if integrated with developmentally appropriate procedures, elicit young children's development and learning in similar ways (Rogow, 2014). Though research on the whole is inconclusive, e-learning activities are generally considered as effective as traditional EC activities, and the interaction between digital technologies and young children is generally regarded as an important factor of the effectiveness of e-learning in EC. For example, Sandvik et al. (2012) explored how a preschool teacher successfully scaffolded four young children's language and literacy learning while they were actively involved in e-learning activities. Regardless of whether digital technologies are being independently accessed by young children or facilitated by adults, they have the potential to support literacy learning and development in diverse ways (Baker, 2017; Dutta, 2017; Karemaker et al., 2017).

As young children grow from infancy, their language and literacy skills develop together (Battle, 2009). Language, differentiated from literacy, is defined as "a system of symbols used in communication" (Harris & Hodges, 1995, p. 132). Literacy is "the ability to read" (Harris & Hodges, 1995, p. 140). Hence, improving young children's language and literacy skills has been the main focus of ECE. In many countries, young children have long been taught various language and literacy skills as preparation for school readiness. Facilitating young children's language and literacy learning to be school-ready is crucial for future school success. In short, they need these skills to transition from learning to read to reading to learn.

Owing to young children being actively engaged in interactions with digital technologies in everyday life (Jack & Higgins, 2019), the EC context of building young children's language and literacy skills has become complex. Many parents and teachers are unsure of how to choose appropriate e-learning activities for certain aspects of early language and emergent literacy (Korat & Segal-Drori, 2016) and, indeed, e-learning EC programs with different digital technologies have shown varying

degrees of effectiveness in improving young children's language and literacy skills in experimental studies (Verhoeven et al., 2020). Thus, the constant influx of change with regards to the use of digital technologies in e-learning requires a systematic examination of the research that has taken place in the past two decades. This will enable ECE researchers to have a better understanding of what work has been done and what work is still left to do if they are to elucidate the proper use of digital technologies for young children.

### *Previous Reviews*

Previous reviews on the use of digital technologies in EC language and literacy education show the issues faced by both parents and ECE teachers; namely, issues regarding the quality of digital technologies for e-learning and their effectiveness. For example, although using e-books is a convenient and popular form of digital technology used to teach young children, Korat and Shamir (2004) pointed out that most of the 43 Hebrew e-books for young children they reviewed lacked standard design regarding multimodal text (e.g., printed and spoken text), interactive features, and storylines. In another comprehensive review, Zucker et al. (2009) found only seven experimental studies utilized a randomized trial to examine the effects of e-books on literacy and language outcomes of children from pre-kindergarten to grade five. Of these seven studies, five reported small-to-medium effect sizes of e-books on reading comprehension. The other two discussed decoding-related literacy skills, thereby preventing sound conclusions. Furthermore, Herodotou (2018) undertook a systematic review on young children from 2009 to 2017 where she found that among the 19 included publications, nine studies found the effectiveness of digital technologies in fostering language and literacy skills in young children. In another systematic review, Kalati and Kim (2022) reported that among the 53 included studies, 34 of them attested to the positive effectiveness of digital technologies on young children's learning. They further found that children's learning using touch screens can be enhanced through implementing more strategic use of touchscreens such as considering the content and features of applications, adult mediation, instructional group, children's age, and their experience with touch screens. Recently, Tang et al. (2020) examined the evolution of using e-books to teach language and literacy in all levels of education. The researchers concluded that digital technology used with young children was especially popular across multiple domains and in need of further investigation.

Hsin et al. (2014) found that the major factors influencing the effects of e-learning were adults' roles and young children's gross and fine motor skills. In a meta-analysis

on intervention studies, Verhoeven et al. (2020) analyzed 59 studies from 57 journal articles published between 1995 and 2017 that investigated the effects of computer-supported early language and literacy education of children from kindergarten to grade one. The meta-analysis results showed great variation in the effectiveness of e-learning on early language and literacy learning and highlighted the limited scope of previous reviews. For instance, most reviews of digital technologies in ECE have focused on e-book interventions and evaluations, leaving other digital technologies beyond consideration. Recently, the advantages of using touch-screen devices for various activities has become apparent and is worth investigating. Concrete recommendations withstanding, previous work provides a sound starting point for this paper, which seeks to provide a comprehensive map of research in this area. According to Ford et al. (2021), these concrete recommendations are important since the role of digital technologies in ECE has encountered several challenges especially due to the COVID-19 pandemic.

In the current review, we focus on the use of digital technologies as reported in peer-reviewed journal articles, with special attention paid to the ECE level. ECE is defined as “infant school, preschool, daycare, nursery school, and other educational programs ordinarily for children prior to [their] entrance [into] the primary grades” (Harris & Hodges, 1995, p. 68). Additionally, in following previous high-quality systematic reviews in the field of technology in ECE (e.g., Tang et al., 2020; Toh et al., 2016; Verhoeven et al., 2020), a three-phase analysis for selecting journal articles was adopted: database searching, paper selection, and coding. This paper presents a comprehensive view of the use of digital technologies in EC language and literacy education over the past two decades and identifies some possible future research directions. The following research question helps to guide the presentation of the findings:

How have digital technologies been used to investigate children’s early language and emergent literacy gains during EC?

## Method

To gather relevant articles to review, we followed established PRISMA guidelines (Page et al., 2021) and implemented identification and selection strategies using specific keywords in the Web of Science (WOS) Core Collection databases: SSCI, SCI EXPANDED, A&HCI, and ESCI. By following previous review studies, we selected WOS since it provides an extensive coverage of peer-reviewed publications in social sciences (Norris & Oppenheim, 2007; Soyoof et al., 2023). Figure 1 outlines the searching and inclusion process, which is explained in further detail below.

### Phase 1: Collection

In phase one, inspired by previous review studies (e.g., Tang et al., 2020; Toh et al., 2016; Verhoeven et al., 2020), we used the following key words: TS = (“digital literac\*” OR “e-book\*” OR “eBook\*” OR “electronic book\*” OR “e-read\*” OR eRead\*) AND (child\* OR infan\* OR toddler\* OR kindergarten\* OR “pre-school\*” OR preschool\* OR “pre-primary” OR “day-care\*” OR daycare\* OR “head start”). Next, the identified articles were restricted to peer-reviewed journal articles because they meet the “minimum standards of methodological quality” (Verhoeven et al., 2020, p. 4). Furthermore, the articles had to be published in English (a noted limitation) to enable multiple reviewers to participate in coding. Duplicate records were removed using automated methods and then checked manually. As a result, we started the synthesis with 587 journal articles published from 1992 to 2021, dates that coincided with previous synthesis papers stating that e-learning in ECE started to increase in the early-1990s (Verhoeven et al., 2020). However, this study extends Verhoeven et al.’s (2020) study in two aspects. First, this review included studies from 2019 to 2021 where the COVID-19 pandemic adversely affected ECE education centers, and the idea of using online resources was felt more than ever. Secondly, this study examined the early vocabulary knowledge of children which was not been explicitly explored in Verhoeven et al.’s (2020) study.

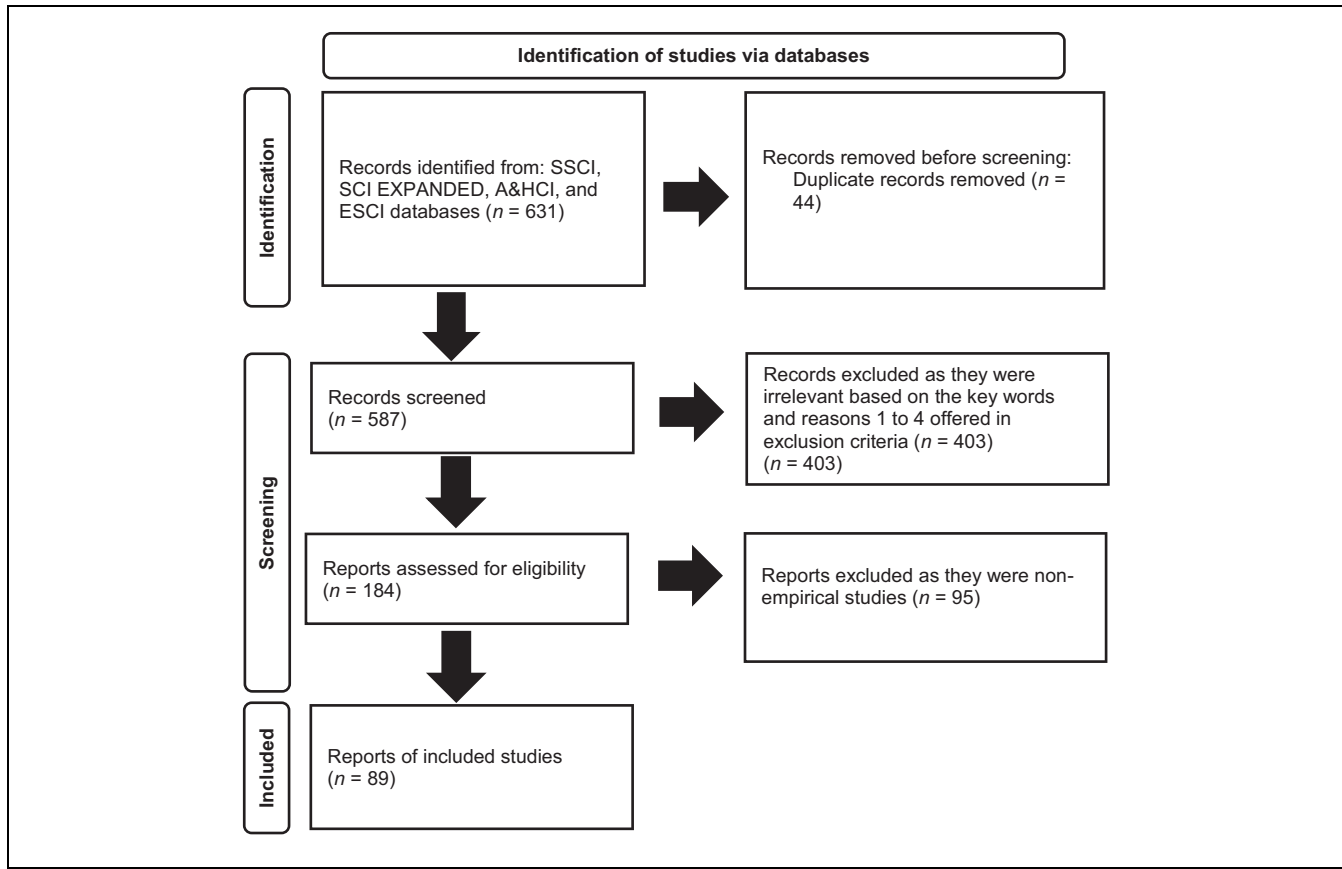
### Phase 2: Applying Exclusion Criteria

In the first phase, we excluded duplicated publications which contained 44 of the studies. In the second phase, we excluded 403 irrelevant publications due to the following reasons:

- Reason 1: Article did not mention the use of e-learning in language and literacy education.
- Reason 2: Article reported solely on e-learning for young children with special needs.
- Reason 3: Article reported on e-learning in primary, secondary, and tertiary education.
- Reason 4: Article reported only teachers’ and/or parents’ attitudes, perceptions, and beliefs about e-learning.

In the last stage, non-empirical studies were excluded.

As shown in Figure 1, we screened the abstracts of 587 articles, then we removed 403 of the publications as they were irrelevant to the keywords selected for this study including 102 articles for Reason 1, 71 for Reason 2, 194 articles for Reason 3, 36 articles for Reason 4. A further 95 articles were excluded since they were not

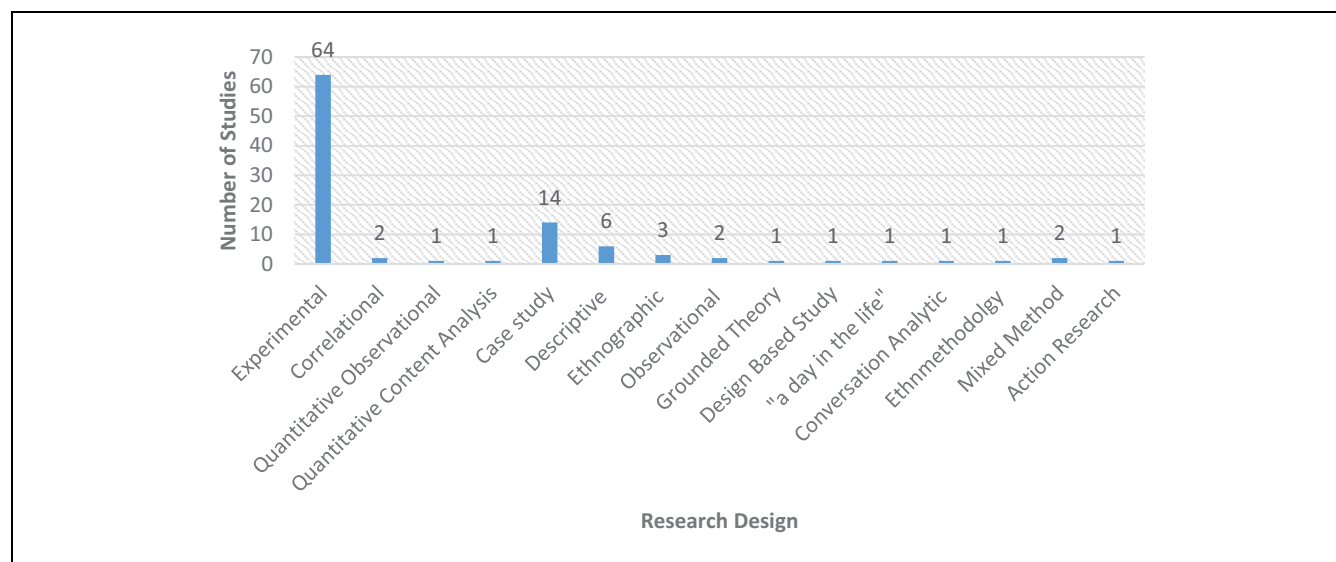


**Figure 1.** PRISMA diagram outlining the selection process.

empirical studies. After applying the five exclusion criteria, 89 included publications were reviewed for this study. To adhere to quality assessment, the included papers were read and assessed by the first author two times with a 2-month time period in-between, and if the first author faced any issue, she consulted with the second and third authors to omit any study that did not meet the inclusion criteria. This process was fulfilled by reading and analyzing the 89 included publications.

**Phase 3: Coding of the Selected Studies.** To guide our initial analysis and begin to answer our research questions, we used NVivo 12 Plus and EndNote 20 to code the selected studies. We assigned codes (called “nodes” in NVivo) for the following factors of each selected study: characteristics of the journal article (i.e., publication title, publication year, and country); demographic information of the participants (i.e., age, socioeconomic status, and language); research designs (e.g., quantitative non-experimental designs: mixed-methods, longitudinal, and correlational design; quantitative quasi-experimental designs; and qualitative designs: case studies, grounded

theory, ethnographic, and observational designs); research processes (e.g., the duration of the intervention, the research sites, and the sample size), digital technologies used (i.e., software: apps, e-books, games; hardware: computers, tablets, game consoles), and literacy outcome measures (e.g., vocabulary learning, story comprehension, and reading engagement). The specificity of the codes was checked against both previously published review papers (e.g., Hsin et al., 2014; Toh et al., 2016; Verhoeven et al., 2020) and *The Literacy Dictionary* (Harris & Hodges, 1995). Furthermore, to ensure coding reliability, we adopted the test-retest strategy, in which the first author coded the 89 journal articles twice with a 2-week interval in-between the two rounds of coding. Average agreement was 98.88%, showing satisfactory agreement across various selected journal articles and codes. These codes were then checked by the second and third authors. Since the included publications offered information about the five above-mentioned codes, we have considered them for this study. If they did not provide the required information based on our five codes, they were omitted as they did not pass the quality assessment process.



**Figure 2.** Number of studies per research design category.

## Findings and Discussion

Before discussing the findings in depth, we provide a general overview of the article pool's characteristics. This is followed by detailed discussion of the findings in five subsections: print knowledge, alphabet knowledge, phonological awareness, early vocabulary knowledge, and narrative skills. Each subsection concludes with practical implications.

### General Overview of the Selected Studies

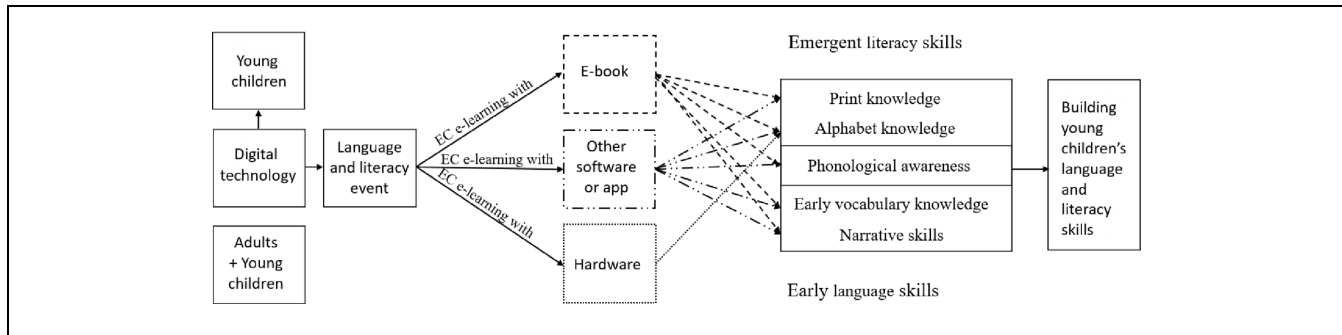
Generally, the 101 studies we reviewed from the 89 selected papers were methodologically diverse, as presented in our systematic map (see Appendix A). Sixty-eight of the 101 studies employed a quantitative research approach. Sixty-four of these studies used experimental designs (pre-test/post-test), in which some had a control group. Two studies were conducted with correlational designs. One study was conducted with a quantitative observational design, and one study was conducted with a quantitative content analysis design. Thirty studies employed a qualitative research approach. Among the qualitative studies, 14 were case studies; six were descriptive studies; three were ethnographic studies; two were observational studies; one was a grounded theory study; one was a design-based study; one was "a day in the life" study; one was a conversation analytic study; and one was an ethnmethodology study. In addition, there were two mixed methods studies and one action research study (See Figure 2).

Furthermore, within-subjects and between-subjects designs with pre-tests and post-tests were the most common designs among the 64 experimental studies. Data

typically included assessment scores of young children's language, emergent literacy, and digital literacy skills. The two correlational studies explored the factors that influence young children's language and emergent literacy skills during e-learning. In the 30 studies employing a qualitative research design, 14 case studies offered a deeper understanding of how young children acquire both language and emergent literacy skills through interaction with a variety of digital technologies during e-learning. Further, the one quantitative observational study and two qualitative observational studies described real-life situations in which young children interacted with digital technologies.

### The Use of Digital Technologies for Building Young Children's Language and Literacy Skills

In general, digital technologies have been used to support various teaching and learning aims within EC language and literacy education. As illustrated in Figure 3, the studies we reviewed focused primarily on links between language and literacy events and building young children's early language and emergent literacy skills. These links were mediated mainly through three groups of digital technologies: e-books, other software and apps, and hardware. In brief, 43 (39.09%) of the studies had specifically investigated the use of e-books. However, around 10 (9%) of the studies addressed other types of e-books (e.g., CD-ROM story books, multi-media story books, and digital books). Additionally, 37 (33.63%) of the studies focused on the use of software and apps; and 11 (10%) of the studies reported on the use of hardware. Since nine of the included publications (i.e., Eng et al.,



**Figure 3.** Framework for the use of digital technologies in EC language and literacy education.

2020; Friedrich et al., 2017; Korat & Segal-Drori, 2016; Laidlaw & Wong, 2016; McKenney & Voogt, 2009; Parish-Morris et al., 2013; D. J. Smeets & Bus, 2012; Yow & Priyashri, 2019; Zipke, 2017) reported more than one study within each publication, the total number of reviewed studies was 110. Overall, multiple and overlapping emergent literacy and early language skills were measured as their dependent variables.

A language and literacy event in ECE is defined as “the construction of meaning” (Zarra, 1999, p. 17). By either accessing the digital technologies independently or with the support of adults, young children constructed meaning through various language and literacy events. In these events, young children expanded, extended, and clarified the print to make the written form of the words meaningful. We categorized the young children’s early language and emergent literacy gains into five categories: print knowledge, alphabet knowledge, phonological awareness, early vocabulary knowledge, and narrative skills (See Figure 3). This categorization is in line with the EC literature as “language and literacy develop together” in EC (Strickland et al., 2004, p. 86). According to Puranik et al. (2011), emergent literacy skills include “alphabet knowledge, phonological awareness, [and] print knowledge” (p. 2). Early language skills encompass not only the knowledge of early vocabulary and narrative but the awareness of phonological knowledge (Shing, 2013, p. 1397). Each of these five categories of language and literacy skills will be reported on in turn. As mentioned earlier, most of the studies in this review measured multiple and overlapping emergent literacy and early language skills in each of their investigations. Therefore, some studies were grouped under more than one category.

*The Use of Digital Technologies to Develop Print Knowledge.* One third (33.33%) of the studies had examined the use of digital technologies in promoting print knowledge, which, according to Puranik et al. (2011), encompasses understanding the distinction between print

and pictures, the distinction between letters and numbers, as well as the conventions of print, such as having the knowledge that words are separated by spaces and that writing follows a linear arrangement. Key sub-skills of print knowledge include “letter knowledge, concept of word (i.e., letters can be combined to form words and spoken words can be represented by words in print), and the understanding that print is read from left to right, often called text directionality” (Skibbe et al., 2018, p. 420). Studies categorized under this section demonstrated two main practice notions that fostered print knowledge gains: interactive and/or multimedia features of the digital technologies and support from adults to facilitate the e-learning incidences.

The results from the quantitative studies reviewed suggest that interactive and multi-media features served as an important technique for promoting print knowledge, which in turn was associated with increased gaze fixation on print compared to simply reading the print texts or standard digital texts. As revealed by the following studies, this may be a practical strategy when selecting and developing e-learning interventions for EC language and literacy education. For example, Kelley and Kinney (2017) found that preschoolers who had experienced using an interactive iPad application storybook had significantly greater gains in print knowledge of English than the control group in the regular preschool program which only used print books. In the same way, Zipke (2017) found that low and middle socioeconomic status (SES) preschoolers gained more print knowledge of English in a 1-hr session using an iPad application storybook than those using a print copy of the same book.

To further investigate the use of e-books on print knowledge, Skibbe et al. (2018) recorded the gaze fixation on print of English-speaking children in preschools. They found that young children’s gaze fixations were longer when they looked at the read-aloud and highlighted e-book pages than when looking at only the read-aloud e-book pages and the silent e-book pages. In addition, Yow and Priyashri (2019) examined middle SES English

and Mandarin bilingual young children's attention to print through dual-language e-book use. The researchers, who conducted the study in childcare centers, found that e-books with enhanced multimedia features (e.g., audio narration and animated pictures) helped attract the young children's attention to print. In a more recent study, Elimelech and Aram (2020) carried out a 4-week digital spelling intervention with a group of low SES Hebrew-speaking preschoolers. Their results showed that children using a digital spelling game with embedded audio and video support outperformed others using a game without embedded audio and video support. In addition, both digital spelling game groups outperformed the control group, who used ordinary e-books.

Apart from the interactive and multimedia features of the digital technologies, adult support available during e-learning helped young children achieve the most gains; perhaps the adult support helped the young children "to assign meaning to what they hear[d]" (Skibbe et al., 2018, p. 425). Hence, adult support could be considered another technique used to promote children's print knowledge. This can be seen in the following studies.

Korat et al. (2013) conducted a 2-week study at low-SES Hebrew-speaking young children's homes. The researchers found that children using e-books were as efficient as those using print books, so long as they received parental support. In contrast to the previous research of Korat et al. (2013), 3 years later, a study by Korat and Segal-Drori (2016) found that the group using e-books with adult support was more effective than the group using print books with adult support; both of those groups were more effective at learning print knowledge than the young children who read e-books alone. The differences between these two studies were the ECE context and the intervention duration. In the later study, the intervention duration was only 20 min and was conducted in kindergartens with adult support. Similarly, Maureen et al. (2018) conducted a 3-week digital storytelling intervention with a group of young children in Indonesian preschools. They noted more significant gains in print knowledge by children in the digital storytelling group (i.e., the teacher played the digital story) than in the standard storytelling group (i.e., the teacher told the story). These two groups also outperformed the control group.

Furthermore, the findings of the qualitative studies reinforced the findings presented above with detailed elaborations on both the features of the digital technologies and the concrete strategies that adults used to support e-learning in different ECE settings. For instance, Noorhidawati et al. (2015) illustrated the situation in which learning took place while Malaysian young children interacted with mobile apps. The researchers observed 18 young children's techno-literacy practices

and argued that the existing features in electronic story-book apps, such as read-out loud narration and animated hotspot features, appear insufficient in maintaining children's engagement. Alternatively, they encouraged parents and teachers to consider using new features such as role-plays and embedded dictionaries. More importantly, they recommended providing adult support for young children's techno-literacy activities through active participation in e-learning. In the same year, Wohlwend (2015) observed three US young children's e-learning experiences in kindergarten. The researcher noted that digital literacy practices emerged during peer collaboration with digital apps on touchscreen devices. During playful peer support, young children linked print to meaning. Hence, Wohlwend argued that "the crowded collaboration around a single touchscreen looks messy but produces a complex text built with ... touches, swipes, and other embodied actions that make up digital literacy practices" (p. 154). In a more recent case study, Kumpulainen et al. (2020) illustrated a situation in which the use of digital technologies was intertwined with two Finnish young children's gains of print knowledge at their homes with guidance from their parents. The researchers made a similar argument that parents need to actively participate in their children's digitalized childhoods to prepare them for ECE success at school.

This section reported on the effects of digital technology use on young children's gains in print knowledge. While digital technologies have been recognized as efficient tools for building print knowledge, only one-third of the studies that measured print knowledge skills and/or sub-skills had reported effect sizes with any large variation (See Appendix A). This finding is congruent with the meta-analysis by Verhoeven et al. (2020) that found a large degree of variation in effect sizes among studies, but contradicts the comprehensive review by Zucker et al. (2009) in which the researchers found only a few experimental studies provided effect sizes. One reason for this discrepancy between Zucker et al. (2009) and our review could have been due to the growing number of research studies in the past decade. Moreover, 7 years have passed since Hsin et al. (2014) identified adult support as one of the major factors influencing young children's ability to learn while using digital technology. Yet, we still found only a few qualitative studies that had described adult support in detail (e.g., how young children could actually learn print knowledge throughout the interaction process with digital technologies at their homes with no ECE pedagogical guidance from teachers). Nevertheless, the studies presented in this section demonstrated two main practice notions: the importance of interactive and/or multimedia features of digital technologies and support from adults.



*The Use of Digital Technologies to Develop Alphabet Knowledge.* Only one (1.12%) of the studies had specifically examined the use of digital technologies on young children's gains in alphabet knowledge, defined by Evans et al. (2017) as "the names and sounds of letters" (p. 1). As one of the key aspects of emergent literacy skills, alphabet knowledge was further defined by Maureen et al. (2020) as the knowledge to recognize the shapes and names of the letters in the alphabet, to write the letters in the alphabet, as well as to determine their corresponding sounds. In the following examples, three main practice notions support alphabet knowledge gains: access to tablets, digital storytelling, and custom digital spelling games.

First, access to digital hardware (i.e., tablets) has been associated with young children's alphabet knowledge gains. Neumann's (2014) correlational analysis showed a positive association between children's access to apps and alphabet knowledge. Neumann (2014) examined 109 English-speaking Australian preschoolers and concluded that those who accessed tablets more frequently at home for writing had greater knowledge of the names and sound of the letters than preschoolers who used tablets less frequently. Similarly, in Parks and Tortorelli's (2021) mixed-methods study, the researchers noticed that young children who had experience with digital math resources on tablets had greater gains in English alphabet knowledge than the control group with regular resources on tablets. Young children's alphabet knowledge had benefited from access to the tablets even when the tablets were not used to study language arts. The researchers explained that young children may have gained alphabet knowledge from "simply spending time navigating the tablets... [as they] often need[ed] to use partial alphabet cues, like initial letters, to find and use applications" (p. 12).

Second, results from the reviewed quantitative studies suggest that digital storytelling and digital spelling games served as more efficient techniques associated with increased learning gains compared to traditional literacy activities. As revealed by the following examples, this may be a practical strategy when selecting and developing e-learning interventions with special focus on the alphabet knowledge aspect of emergent literacy skills. For example, Maureen et al. (2018) conducted a 3-week storytelling intervention in preschool classrooms. The researchers compared knowledge gains from groups of children receiving three types of input: traditional ECE storytelling activities, digital storytelling activities, and regular ECE literacy activities. The results showed that young children receiving the digital storytelling input displayed greater learning gains in alphabet knowledge than those in the traditional ECE storytelling group and the control group. Two years later, the same researchers

(Maureen et al., 2020) carried out a 6-week storytelling intervention in kindergarten classrooms. The researchers compared knowledge gains from groups of children receiving three types of input: regular literacy activities, storytelling with play-based activities, and digital storytelling and activities. The results showed that a combination of structured EC literacy storytelling instructions with associated activities, either in transitional ECE forms or digital forms, could equally support young children's alphabet knowledge gains. The differences between these two studies were intervention duration and adult support. In the later study, the intervention was conducted for twice as long. The novelty effects of digital storytelling might have been reduced by the more extensive intervention period in the later study. Hence, the digital storytelling intervention and traditional storytelling intervention were equally effective in promoting alphabet knowledge gains.

Alternatively, it appears that digital spelling games could be another technique for promoting alphabet knowledge. For example, Elimelech and Aram (2020) conducted a 4-week digital spelling game intervention with 129 Hebrew-speaking preschoolers in classrooms. The researchers tested knowledge gains on four conditions when viewing fiction e-books: using digital spelling games with no support, auditory support, both auditory and visual support, or the control condition, viewing fiction. The results showed that while young children under the three different digital spelling game conditions displayed greater learning gains in alphabet knowledge than those under the control condition, no significant differences were found among the three intervention conditions.

On the contrary, alphabet e-books seemed less effective than print alphabet books in promoting young children's alphabet knowledge gains. In one study, Willoughby et al. (2015) carried out an 8-week alphabet e-book intervention with a group of English-speaking young children. They compared alphabet knowledge gains in a classroom setting between groups using either an alphabet e-book or an alphabet print book. Their results showed no significant differences between the two groups. Two years later, Evans et al. (2017) carried out a 10-week alphabet e-book intervention with a similar group of young children. They compared children's alphabet knowledge gains in the classroom from using an e-book with various audio and interactive features to gains using a print book with various text and illustration styles. Their results showed the children using the alphabet print book outperformed those using the alphabet e-book in their ability to say letter names. Furthermore, young children spent more orientation time on the alphabet e-books during the first three quarters of the intervention period. Additionally, their letter-related behavior



(e.g., the behavior of saying letter names and object names) declined over those sessions. This was probably because the teachers provided a lot of orthographic-specific guidance during the print book reading sessions.

In contrast to the quantitative study results, Rowe and Miller (2016, p. 9) illustrated a situation in which the multimodal, multilingual, multiply sponsored e-book activities (i.e., an “easy and immediate incorporation of digital photos and oral recordings into eBook products allow[ing] children, their families, teachers and researchers to share sponsorship of the content”) were designed by both teachers and Spanish-English bilingual young children. These young children played a multimodal, multilingual composer role in the design process. Their teachers played a facilitator role in helping the young children “in using their developing alphabet knowledge to invent spellings for words” (p. 435). Also, the inconsistent findings of the qualitative study and the quantitative studies of alphabetic e-books were congruent with the argument by Rogow (2014) that if integrated into e-learning with developmentally appropriate procedures, digital technology embedded activities are as effective as traditional ECE activities.

This section reported on the use of digital technologies on young children’s alphabet knowledge gains. While alphabet knowledge has been recognized as a key aspect of emergent literacy skills, only the aforementioned studies specifically investigated the use of digital technologies as related to alphabet knowledge. Besides, only one qualitative study described situations in detail regarding how young children could actually construct alphabet knowledge throughout the interaction process with digital technologies in their classroom where teachers’ orthographic-specific guidance was available. Nevertheless, the studies in this section demonstrated three main practice notions to support alphabet knowledge gains: access to tablets, digital storytelling, and custom digital spelling games.

*The Use of Digital Technologies to Develop Phonological Awareness.* About 25% of the quantitative studies reviewed mentioned phonological awareness, which Ihmeideh (2014) defined as “the ability to notice, think about, or manipulate the individual sounds in words” (p. 41). Key sub-skills under phonological awareness are “rhyming words, phoneme blending, phoneme identification, and phoneme segmentation” (Ihmeideh, 2014, p. 41). In general, the use of e-books and digital spelling games contributed to gains in young children’s phonological awareness. Studies in this section demonstrated four main practice notions which fostered phonological gains: interactive and/or multimedia features of the digital technologies, support from adults to facilitate e-learning incidences, paired peer learning, and the intensity and/or duration e-book reading sessions.

Interactive and/or multimedia features of e-books and digital spelling games support young children’s phonological awareness gains. For example, Korat and Segal-Drori (2016) assigned 128 low-SES Hebrew-speaking young children into four different groups: those using either an e-book, an e-book with adult support, or a print book with adult support, and the regular kindergarten program (the control group). The duration of the one-time reading session was around 15–20 min. The results showed that young children who participated in e-book reading with adult support gained an advantage in phonological awareness over their peers who participated in print book reading with adult support. Similarly, in a more recent study, Elimelech and Aram (2020) carried out a 4-week digital spelling game intervention with a group of 129 low-SES Hebrew-speaking preschoolers in classrooms. The researchers compared learning under four conditions: using digital spelling games with no support, using digital spelling games with auditory support, using digital spelling games with both auditory and visual support, and viewing fiction e-books (the control). Young children in each condition participated in eight 20-min sessions during the intervention. The results showed that the group that used the digital spelling games with embedded audio and video support outperformed the digital spelling game group. In addition, all digital spelling game groups outperformed the control group that used ordinary e-books. The aforementioned two studies gave superiority to the interactive and/or multimedia features of digital technologies over a lack of integrative features of print books.

Having adult support influenced young children’s phonological awareness gains. Korat and Shamir (2007) carried out a 30-min storybook intervention with a group of 128 low- and middle-SES Hebrew-speaking young children. The researchers compared three conditions: young children individually reading the e-book, adults reading the print book, and young children participating in the regular kindergarten program (the control). The results showed that only low-SES young children from the e-book reading group gained more phonological awareness skills than their middle-SES peers. In another short intervention, Korat et al. (2009) conducted a 15-to-20-min e-book intervention with a group of 128 low-SES Hebrew-speaking young children. The researchers compared four conditions: young children read the e-book independently or with adult support, read the print book with adult support, or participated in the regular kindergarten program (the control). The results showed that the young children whose initial literacy level was low gained more knowledge of closing sounds from the e-book reading with adult support than their peers who received print book reading with adult support.

In a similar intervention with a longer reading session of 60 to 80 min, Segal-Drori et al. (2010) compared a similar sample under four conditions. These researchers compared the use of an e-book with instruction, an e-book without instructions, a print book with instructions, and the regular kindergarten program as the control. The researchers found a similar result to the study conducted by Korat et al. (2009). Young children participating in the e-book group who received instruction made greater progress in phonological awareness than those using the e-book without instruction or the control group. No differences were found between the print book with instructions and the other three groups. Three years later, Korat et al. (2013) conducted a 2-week e-book intervention. The participants were 90 low SES Hebrew-speaking young children and their parents at their homes. The researchers compared the effects on young children's phonological gains when using an e-book with parental support to using a print book with parental support. The results showed that young children whose initial literacy level was low gained more phonological awareness skills (i.e., syllabic skills and sub-syllabic skills) from the e-book reading with parental support than their peers. Moreover, the parents used a higher level of support in the e-book reading group. In brief, given the evidence that digital technologies can help young children from a low SES and/or with low early literacy levels gain phonological awareness skills, research-informed practice efforts should optimize adult support and utilize the e-book and/or digital story reading sessions as an evidence-based ECE activity for young children's phonological awareness gains.

Paired peer-learning with e-books supports young children's phonological gains. For example, Shamir et al. (2008) conducted a 2 hr and 30 min hour intervention with a highly rated commercial e-book and a group of 110 low-SES Hebrew-speaking young children. Learning outcomes under four conditions were compared in this study: the tutor with an e-book, the tutees with an e-book, the individual learner with an e-book, and the regular kindergarten program. In general, young children from the three e-book conditions outperformed those in the regular kindergarten program. Also, children under the tutor and tutee with e-book conditions performed better in a phonological awareness assessment than those working individually with e-books.

The intensity and/or duration of the e-book intervention influenced young children's phonological gains, as revealed by Korat and Segal-Drori (2016), who investigated the effects of e-book reading on phonological awareness. A group of 214 low-SES Hebrew-speaking young children were randomly assigned to study under one of three conditions: five sessions of e-book reading, three sessions of e-book reading, or the regular

kindergarten program (the control). The duration of each e-book reading session was around 15 to 20 min. No adult support was provided. The results showed that the young children participating in five sessions of e-book reading gained an advantage in phonological awareness over those in the control group. However, no significant differences were found between the control group and the children participating in three sessions of e-book reading.

It is worth noting that a certain type of e-book appears relatively ineffective in building young children's phonological awareness. Willoughby et al. (2015) carried out an 8-week alphabet e-book intervention in a classroom setting with a group of 94 English-speaking young children. They compared the phonological gains made by children using an alphabet e-book with gains by those using an alphabet print book. Their results showed that the use of both e-books and print alphabet books were relatively ineffective at building phonological awareness. This finding is in line with the review of different e-books by Korat and Shamir (2004) in which the authors argued that the characteristics of e-books for young children need to be carefully selected according to the congruence of the book contents and language and literacy skills.

This section reported on the effects of digital technology use on young children's phonological awareness gains. While nearly 25% of the quantitative studies covered emergent literacy and early language skills, none of the qualitative studies reviewed focused on exploring the effects of digital technologies on phonological awareness and/or its sub-skills. This may be explained by the fact that most qualitative studies were primarily focused on the overall emergent literacy and early language skills in which different e-learning situations were explored in detail. As revealed by the studies which focused on phonological awareness gains, four main practice notions were identified: interactive and/or multimedia features, adult support, paired peer learning, and intensity and/or duration of the intervention.

*The Use of Digital Technologies to Develop Early Vocabulary.* Around one quarter (25%) of the quantitative studies and one qualitative (3.22%) study covered early vocabulary, which referred to "those words known or used by a person or group" (Harris & Hodges, 1995, p. 274). Vocabulary development is defined as "the growth of a person's stock of known words and meanings" (Harris & Hodges, 1995, p. 275). In general, the use of e-books and story apps contributed to young children's vocabulary development and gains. Studies under this section demonstrated four main practice notions which fostered young children's vocabulary development: question features of digital technologies, animated features of digital technologies, support from adults to

facilitate e-learning incidences, and paired online peer learning.

Previous studies have shown that the question features of digital technologies are influential for young children's vocabulary development and gains. For example, Smeets and Bus (2012) carried out two small-scale experiments to investigate the effects of e-book use on young children's vocabulary gains. In the first study, the researchers conducted a 2.5-week intervention with a group of 20 middle-SES Dutch-speaking young children. The children's vocabulary gains were compared among the following three methods: e-book reading with multiple-choice questions appearing during the reading, at the end of the reading, or not at all (the control group). The results showed that the multiple-choice questions of the e-books contributed to the young children's receptive and expressive vocabulary gains. In their second experiment, Smeets and Bus (2012) conducted another 2- to 3-week intervention with a similar sample. The researchers compared the reading of an e-book with multiple questions or hotspots of difficult words' definitions to e-book reading only (the control condition). The results showed that the use of multiple-choice questions was more effective than the presence of definition hotspots in promoting young children's vocabulary gains.

In contrast, in a later study, Zhou and Yadav (2017) conducted a 2-week multimedia story app intervention with a group of 72 English-speaking young children. The researchers compared the effects of four methods on the children's vocabulary gains: using a multimedia story app with or without questions, and using a print story with or without questions. The results showed that when no questions were asked, multimedia was more effective than print at increasing young children's vocabulary. However, no differences were found between the two methods using questions. In addition, there were no differences between the multimedia story app groups with or without questions. A possible explanation for these results is that the questions used during e-learning were different. The questions asked in the Smeets and Bus (2012) study were multiple-choice questions related to vocabulary learning. However, the questions asked in Zhou and Yadav's (2017) study were low and high cognitive demand questions related to the story.

Previous studies have shown that the animated features of digital technologies support young children's vocabulary development and gains. For example, Smeets and Bus (2015) carried out a 4-week e-book reading intervention with a group of 136 Dutch-speaking young children. The researchers compared their vocabulary acquisition after using one of four inputs: a static e-book, an animated e-book, an interactive animated e-book, and the control (young children interacted with nonliterary related computer games). In all conditions,

young children read the e-books or played the games independently. The results showed that the young children who read the interactive animated e-book gained the most vocabulary, followed by those who read the animated e-book and the static e-book, respectively. The pooled three e-book groups achieved higher scores in vocabulary assessment than the control group.

Sun et al. (2019) used animated features in e-books to promote English vocabulary gains. The researchers conducted a 2-week intervention with a group of 102 middle-SES Mandarin-speaking young children by comparing vocabulary acquisition gained while using one of four inputs: an animated e-book with sound and motion, a static e-book with sound, a static e-book without sound, or a math game app (the control). The results showed that the animated features of the e-book were the most efficient at promoting young children's Mandarin vocabulary gains.

Another point worth mentioning is that in some studies, early vocabulary knowledge gains were not influenced by the medium of the books used. For instance, Neuman et al. (2017) conducted an 80-min digital storybook intervention with a small group of 38 low-SES English-speaking young children. The researchers compared children's vocabulary gains from reading storybooks in either digital or print form. The results showed gains were not influenced by the medium of the books; however, they were influenced by the content of the stories. This finding is also in line with the previous review that the content of stories is a factor that influences the amount of learning that can occur from e-book use (Korat & Shamir, 2004).

As revealed by the following examples, when adult support was given, young children benefited more. Korat and Shamir (2007) carried out a 30-min storybook intervention with a group of 128 low and middle-SES Hebrew-speaking young children. The researchers compared vocabulary gains under three conditions: children read the e-book independently, adults read the print book to young children, and young children participate in the regular kindergarten program (the control). The results showed significant improvement in the vocabulary gains of both the children who read the e-book independently and the children to whom adults read the print book. Further, middle-SES children from both input groups gained more vocabulary than their low-SES peers. Seven years later, Korat et al. (2014) carried out another e-book reading intervention. The researchers compared vocabulary gains from four e-book inputs: with adult vocabulary support, dynamic visual dictionary support, static visual dictionary support, and without support (the control). The results showed significant improvements in the groups who read e-books with support over the control condition. To elaborate, adult

vocabulary support was the most effective input for promoting young children's vocabulary gains. Dynamic visual dictionary support was the second most effective input, and static dictionary support was the third most effective input.

In another study focusing on English vocabulary, Roskos et al. (2016) carried out a 4-week e-book reading intervention with a group of 33 low-SES English-speaking young children. The researcher compared gains under three conditions: independent e-book reading, e-book reading with instructions, and independent print book reading (the control). The results showed that the young children benefited the most from reading the e-book with instructions. In a more recent study, Korat, Atishkin, and Segal-Drori (2022) conducted a 4-week e-book intervention with a group of 104 low-SES Hebrew-speaking young children. The researchers compared the children's vocabulary gains from reading an e-book under three different conditions. In the first condition, they were given a dictionary and adult support, the second only a dictionary, and the control neither. The young children given both a dictionary and adult support gained more vocabulary than the children in the other two conditions. More significantly, when a high level of adult support was given, early vocabulary knowledge gains were no longer influenced by the medium of books. For example, Troseth et al. (2020) conducted a 45-min e-book intervention with a group of 32 low-SES English-speaking young children and their parents. The researchers compared the use of an enhanced version of narrated e-books with a control condition where young children interacted with basic narrated e-books. The results showed that young children generally scored well in their vocabulary gains under both conditions. Moreover, in a qualitative study by Christ et al. (2018), paired online peer learning was explored. Christ et al. (2018) described the reading patterns (i.e., hotspot-centric, text-centric, and integrated patterns) in which US and Turkish children dyads engaged with multimodal books for one school year. In brief, these young children gained vocabulary from collaborative social interactions involving e-book applications.

This section reported on the effects of digital technology on young children's early vocabulary knowledge gains. While 25% of the quantitative studies covering this early language skill, only one of the qualitative studies reviewed provided insights into the use of digital technologies in a paired online peer-learning situation where collaborative social interactions were available. This was because most of the qualitative studies explored different e-learning situations rather than focusing on any specific language skills. As revealed by the studies that focused on early vocabulary gains, four main practice notions were identified: the question features of digital

technologies, the animated features of digital technologies, adult support to facilitate e-learning, and paired online peer learning.

*The Use of Digital Technologies to Develop Narrative Skills.* Around 25% of the reviewed quantitative studies covered narrative skills, which included "the ability to understand and tell stories using sophisticated language skills" (Copp et al., 2016, p. 448). Narrative skills are crucial for reading comprehension. These skills can be assessed by story retelling. Multiple sub-skills are associated with narrative skills such as "comprehension of story elements, sequencing, inferencing, understanding of story structure, and semantic and grammatical skills" (Babayigit et al., 2021, p. 150). Furthermore, "narrative skills have been integral to the early theoretical models of comprehension, which emphasized the construction and integration of a coherent mental representation of text or discourse" (Babayigit et al., 2021, p. 150). In general, the use of e-books and story apps contributed to young children's narrative skills regarding their comprehension gains. Studies under this section demonstrated five main practice notions which fostered young children's comprehension gains: paired peer learning, concrete multimedia features, multiple languages, age appropriate ECE features, and support from trained adults.

As revealed by the following examples, the general multimedia features and/or simple interactive features embedded in digital technologies did not contribute more to young children's comprehension gains than they contributed to other emergent literacy skills and early language skills (e.g., print knowledge, alphabet knowledge, phonological awareness, and early vocabulary knowledge). Studies using e-book interventions with simple and direct multimedia features and/or interactive features provided no significant improvements to young learners' comprehension gains. Parish-Morris et al. (2013) conducted a 5-min e-book intervention with a group of 73 middle and high-SES English-speaking parent-child dyads in which one group used an e-book console and the other a print book. The results showed that young children in both groups performed equally well at story comprehension (i.e., the ability to identify characters and events from the stories). In a longer e-book intervention, Smeets and Bus (2015) carried out a 4-week e-book reading program on story comprehension with a group of 123 Dutch-speaking young children. The researchers compared comprehension outcomes among readers using static e-books, animated e-books, interactive animated e-books, and the basic e-books (i.e., control). In all conditions, the children read the e-books independently. The results showed that animation, whether interactive or not, did not contribute to comprehension.

The previous findings were reinforced by Etta and Kirkorian's (2019) study in which an e-book intervention was conducted with a group of 103 middle-SES English-speaking young children. The researchers compared the children's comprehension under three separate conditions: they were allowed to touch a relevant picture on the screen (i.e., relevant-interactive e-book); they were allowed to touch an irrelevant picture on the screen (i.e., irrelevant-interactive condition); or they were asked to observe the experimenter touching the screen (i.e., non-interactive control condition). The results showed that simple interactive features of e-books neither disrupted the story nor hindered the children's ongoing comprehension. Their comprehension did not differ as a function of conditions. In the same year, Yow and Priyashri (2019) conducted an intervention with 39 middle-SES English and Mandarin bilingual young children. The researchers compared using a single language e-book with multimedia features to using one without multimedia features. The results showed that young children's comprehension did not differ as a function of multimedia features.

In a similar vein, the simple and direct multimedia and/or interactive features embedded in digital stories and/or apps neither improved nor hindered young children's ongoing comprehension gains. For example, Zhou and Yadav (2017) conducted a 2-week multimedia story app intervention with a group of 70 English-speaking young children. The researchers compared comprehension among four inputs: those given a multimedia story app with or without questions (two groups), and those given a print story with or without questions (the other two groups). The results demonstrated no significant differences in comprehension due to either the medium of learning (multimedia vs. print story) or the addition of interactive features (i.e., the questions).

Meanwhile, Zipke (2017) carried out a small-scale experiment to investigate the effects of story-book apps on young children's comprehension. The researcher conducted a 1-hr intervention with a group of 25 low and middle-SES English-speaking young children. Comprehension when a pair of children read a story-book app was compared to when a teacher read the print book to a small group. Results showed that children in both conditions were able to retell part of the story, and no significant differences were attributed to the learning medium. In a recent study, Troseth et al. (2020) conducted a 40-min e-book intervention with a group of 32 low-SES English-speaking young children. The researchers compared comprehension using an enhanced e-book with dialogic questioning enhancement to comprehension using a narrative e-book. The results showed statistically equivalent comprehension scores among participants in the two conditions.

Certain combinations of complex multimedia features and/or interactive features were demonstrated effective in promoting young children's comprehension gains. The first feature is being able to interact in more than one language. Yow and Priyashri (2019) investigated the intersection between e-book use and young children's comprehension gains. An intervention with a group of 32 middle-SES English and Mandarin bilingual young children was carried out using a dual language e-book, either with or without multimedia features. Results showed that the children given access to a combination of dual language text with multimedia features had better story comprehension.

In some studies, the combination of animation, non-verbal information, and paralinguistic features made a difference. For instance, Zipke (2017) conducted an e-book intervention with a group of 25 low and middle-SES English-speaking young children. The researcher compared comprehension gains after using storybook apps without and with adult support (specifically, the teacher asked comprehension questions). The results showed that not having adult support was more effective in promoting young children's comprehension. Particularly, in addition to the simple and direct multimedia and/or interactive features (e.g., audio and text highlighting), the selected book apps in this study also included "purposeful embedded animation and interactivity" (Zipke, 2017, p. 1705). Similarly, Altun (2018) conducted a 2-month digital book intervention with a group of 72 middle SES Turkish-speaking young children. One group used a digital book with multimedia features and the other a print book. The results showed that the children using the digital book with multimedia features outperformed their peers in explicit story comprehension, implicit story comprehension, and story recall. Importantly, the multimedia features of the digital book in this study were "animated illustrations, nonverbal information (sounds, music, and effects), and paralinguistic features (gesture, body language, prosody)" (p. 638).

Additionally, child-centered multimedia and/or interactive features were found to be an efficient technique to promote comprehension. Courage et al. (2021) carried out a 3-day digital storybook app intervention with a group of 60 English-speaking young children. The researchers compared groups of children using either a digital storybook app or a print book. The results showed that the children using the digital storybook app recognized more information from the book. In the study by Courage et al. (2021), the digital storybook app had the following characteristics: age-appropriate, topic-focused, and requirements fulfilled of an ECE app (i.e., active, engaging, meaningful to young children, and embedded with interactive features).

Regarding the practical notion of adult support, neither reading aloud nor providing technical support contributed more to young children's comprehension gains than their prior performance at other skills. Neuman et al. (2017) conducted an 80-min digital book intervention with a group of 38 low SES English-speaking young children. The researchers compared two groups of children, one reading a digital book and another reading a print book in-person. No differences were found between the two groups. The results showed that the medium of instruction did not influence comprehension. In another e-book intervention study with a larger sample size, O'Toole and Kannass (2018) studied a group of 100 English-speaking young children. The researchers compared outcomes under four conditions: using an e-book that an adult read aloud, using an e-book with an audio device, using a print book that an adult read aloud, and using a print book with an audio device. The results showed no differences among the four conditions. A similar study was conducted by Reich et al. (2019) with an even larger sample: an e-book intervention with a group of 200 high SES English-speaking young children. The researchers compared learning outcomes between one group of children using an e-book with auto-narration on a tablet and another group using a print book read by an adult. The results showed that the young children in the e-book group did not outperform those in the print book group.

It is worth noting that specific teacher training on how to use digital technologies to support young children's learning was found to be effective in promoting their comprehension gains. For example, in a recent study, Korat, Tourgeman, and Segal-Drori (2022) conducted a 3-week e-book intervention with a group of 160 low-SES Hebrew-speaking young children. Three conditions were compared: reading an e-book with story comprehension supportive expansions and a teacher's support, independently reading an e-book with story comprehension supportive expansions, and independently reading an e-book without support (the control). The results showed that the children benefited the most from reading the e-book with both expansions and a teacher's support, followed by the independent e-reading with expansions, and then the control condition. This finding echoes the review by Hsin et al. (2014) that adult involvement when using digital technologies with young children is a main factor influencing their quality of learning and Shamir et al.'s (2008) study (described above) in which groups using e-books performed better in story comprehension than the individual learners using e-books.

This section reported on young children's comprehension gains while using digital technology. While nearly one-fourth of the quantitative studies covered this aspect of narrative skills, none of the qualitative studies we

reviewed explored using digital technologies to increase narrative skills and related sub-skills. One possible reason for this discrepancy between quantitative studies and qualitative studies is that qualitative studies impose a deeper understanding of various e-learning situations rather than focusing on a specific type of language skill. The studies that focused on narrative skills identified five main practice notions: the use of a dual-language e-book, the concreteness features of multimedia (e.g., interactive features, multiply sponsored features, and paralinguistic features), the age appropriateness for ECE of the digital technologies, the support of adults trained in ECE e-learning, and the practice of paired peer learning.

## Conclusions and Implications

The uses of digital technologies on the early language and emergent literacy skills of young children can be analyzed from five different aspects: print knowledge, alphabet knowledge, phonological awareness, early vocabulary knowledge, and narrative skills. For this paper, 101 studies were reviewed, including 68 quantitative studies, 31 qualitative studies, and two mixed-methods studies. In the quantitative studies, the majority of researchers relied on quasi-experimental methods, implementing various approaches to validate their findings. However, there is a paucity of experimental research to determine with more certainty the effectiveness of interventions (see also Toh et al., 2016). The studies reviewed describe the use of different types of digital technologies with infants, toddlers, and preschoolers. The investigations that were conducted included a series of practical notions designed to advance young children's early language and emergent literacy skills and encourage age-appropriate ECE e-learning practices. Further, it is important to underscore the significant role of formal education (e.g., preschool, daycare, nursery school, and other educational programs ordinarily) for enhancing different skills and knowledge in young learners before primary school. Thus, one of the implications of this study is that different digital technologies can promote language and literacy skills in children. To increase the language and literacy of young children through digital technologies, the role of teachers is central particularly in guiding young children to digital resources (i.e., applications or software) that are appropriate for their age.

Furthermore, the studies reviewed showed that the context also influenced how to use the digital technologies in EC language and literacy education. In addition to young children as the main users of the digital products, teachers' and caregivers' eagerness to adopt new technologies increases the ECE e-learning programs' chances of success. Caregiver support extends e-learning to applications outside the ECE classroom. In brief, past

research indicated various successful examples of the integration of digital technology into ECE literacy teaching. This review paper shows a possible practical roadmap and highlights research gaps in e-learning in the ECE language and literacy domain. This is especially true of our systematic map (see Appendix A), which we hope other researchers will use to guide their own reviews. Hence, another important implication of this study is that implementing digital technologies in ECE can be beneficial provided that children would be mediated by their teachers. In this way, the role of teachers is crucial in guiding children's language and literacy development. For example, it is important for teachers to consider what digital resources and digital practices are more effective to enhance different knowledge in children, namely vocabulary, phonological, alphabet, print, and narrative knowledge.

### Limitations

While this review paper has provided important practical and empirical information, it is not without limitations. First, at the beginning of the review process, we provided one concrete research question to constrain the scope of the search. Hence, the focus of this review paper was the use of digital technologies on the early language and emergent literacy aspects of ECE. Yet, integrating digital technologies into ECE contexts usually reaches a broader group of audiences than the selected studies' participants. As revealed from our original database search with key terms, we came across empirical studies specific to, for example, at-risk and special need young children, special needs EC teachers, speech therapists, and other allied-health professionals. As these audiences were outside our intended scope, we excluded those studies from this review. However, we acknowledge that at-risk and special needs young children are important and deserving of future review studies. One important research topic for future reviews is the use of digital technologies for early language learning and emergent literacy development of at-risk and young children with special needs.

A second limitation was that we only reviewed studies written in English. Hence, a geographical limitation surfaced. For example, no studies we identified from either Japan or Korea were included in our review because those found were not written in English. Hence, further review studies could develop a more comprehensive picture of the use of digital technologies on young children's early language and emergent literacy development if a more international and collaborative group of researchers could be formed so that research written in languages other than English could be included. This limitation extends to the recurrence of certain first-language groups

in our findings as well. Clearly, the research of certain groups tends to dominate the article pool.


### Declaration of Conflicting Interests


The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.


### Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the University of Macau [MYRG2022-00091-FED].

### ORCID iDs

Sylvia Liu  <https://orcid.org/0000-0001-7486-415X>

Barry Lee Reynolds  <https://orcid.org/0000-0002-3984-2059>

Ali Soyoof  <https://orcid.org/0000-0002-8037-5632>

### Supplemental Material

Supplemental material for this article is available online.

### Data Availability Statement

The datasets generated during and/or analyzed during the current study are available from the first author on reasonable request.

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