



Interactive Design Process for Enhancing Digital Literacy Among Children: A Systematic Literature Review

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Abstract. In the field of education, there is a significant amount of literature that focuses on how children's age and cognitive research can improve children's digital literacy. However, little work based has been undertaken exploring the combination of children's digital product design and digital literacy. Although involving children in the design process can improve design quality, it is unclear how participating in the design process affects children's digital literacy. The current study conducted a systematic review of the literature published between 2011 and 2021 on the design process, and found 20 studies that met the inclusion criteria, extracting factors that attach importance to children's values and that enhance their digital literacy in the design process. The majority of the reviewed studies revealed two common ways in which children are included in the interaction design process and influence design decisions; this is usually in the early stage of the design as a provider of design intent and as a tester for product use after the product is completed. But since 2000, there has been a trend to focus on the development of children's digital literacy, and that children are not just consumers of technology. Rather, their role as creators has also received more research attention. The current review aims to provide new insights and suggestions on how to improve children's digital literacy.

Keywords: Digital literacy · Children · Interactive design · Design process

1 Introduction

In today's society, which increasingly communicates and accesses information through digital technologies such as internet platforms, social media, and mobile devices, digital technology brings convenience and benefits to everyone. Digital literacy means possessing the skills and abilities to find meaning from digital information, which means understanding the technology and using it appropriately [1]. To date, much research on information literacy has focused on middle school students, college students, or adults, but the use of digital technology

in early education has increased. Toddlers are increasingly using technology and popular media, and they are starting to use this technology at a younger age. Digital book reading among parents and young children has dramatically increased, and parents and children are increasingly using personal portable devices such as iPads to read stories together. Educating children in digital literacy enables them to understand the technology so that they can use it safely and effectively. A study of digital literacy practices in schools and at home for children in Sweden, Norway, and Australia states that digital literacy is reflected in “activities that encompass verbal, embodied, and social competencies”, such as the ability of children to guide each other and solve problems [2–4]. Almost any industry that children will move into as adults will require some form of digital literacy, and these skills will best assist them in their further studies and careers.

Research on interaction design such as for touch screens includes the ability of users to understand digital content in a sociocultural context; for example, the ability to understand the meaning of symbols, the haptic ability to touch and click, and the ability to take actions based on audio instructions and prompts [2]. In terms of use by children, their cognition affects their touch-based interactions, and children’s understanding of the interface is based on their skills at specific stages of their development [5]. In the field of children’s digital products, much research has been conducted on children’s cognitive and design uses. For example, designers and researchers often incorporate an interpretation of what a child is and how children learn. However, children’s involvement in the design process has been little explored. Despite the strong evidence regarding children’s products that user experience must be centred on children’s needs, how to obtain, quantify and evaluate children’s user needs is one of the least discussed and most ambiguous aspects of the design research on user experience. Many children’s digital product designs are modelled on the values and needs of adults, not children. In order to enhance children’s digital literacy, more research in children’s digital product design is needed, especially that which could result in better quality apps for enhancing children’s creative activities. The current article provides a review of design research centred on enhancing children’s digital literacy from the perspective of interactive design.

This research aims to explore the assumptions related to the concept of digital literacy present in the area of designing for children, how these influence design decisions, and the impact that children make by participating in the design process. The current review covers common interactive design methods and recent research developments. This study hopes to explore the following questions:

- How does including children in the interaction design process relate to improving children’s digital literacy?
- What are some common ways of including children in the design process and influencing design decisions?

2 Method

Published literature pertaining to children’s digital literacy was retrieved from two databases, Web of Science and Scopus. A systematic search was performed

using a comprehensive combination of keywords, employing a search string containing three main parts: (1) keywords related to children’s digital literacy; (2) keywords related to design; and (3) subject area specifications. Articles may have multiple subject areas in Web of Science and Scopus. To avoid a large number of false positives, we excluded natural sciences and medical sciences.

The search targeted the metadata (title, abstract and keywords) of the paper, not the entire text, and it yielded 1,586 entries. This research tabulated individual programs and systematically coded for quality to review the evidence base, based on the scope and nature of the data report. The complete search string is provided in Table 1.

We identified the following inclusion criteria for the articles. They needed to be

- written in English;
- research on or evaluations of the user experience of children using digital products;
- related to primary school-aged children (3 to 12 years);
- concerned with outcomes related to children’s digital literacy; and
- published between 2011 and 2021; SCI\SSCI\A & HCI.

Table 1. Search syntaxes

<i>Database</i>	<i>Search terms</i>
Web of Science	Search #1 (“digital literacy” [Topic]) AND (child* [Topic])
	Search #2 (“digital literacy” [Topic]) AND (*design* [Topic])
	Search #3 (“digital literacy” [Topic]) AND (interact* [Topic])
	Search #4 (“digital literacy” [Topic]) AND (creat* [Topic])
Scopus	Search #1 intitle: (“digital literacy” AND “child”)
	Search #2 intitle: (“digital literacy” [Topic]) AND (*design* [Topic])
	Search #3 intitle: (“digital literacy”) AND (interact* [Topic])
	Search #4 intitle: (“digital literacy”) AND (creat* [Topic])

3 Results

This section describes the results of the review. As described in the Method section, a manual search was conducted in the selected journals. Figure 1 shows

the steps of the literature searches of a total of 1,586 articles that mentioned digital literacy. Duplicated articles and articles unrelated to this topic were excluded, and 164 articles were identified that engaged with children and mentioned design. We then excluded 119 records based on their abstracts and 25 papers based on their full-text articles, following the exclusion criteria. Of the 18 studies that discussed empirical research on children's interaction with technology, five were found to be studies discussing the involvement of children in the design process and 13 were found to be studies of the effects of technology on children's lives and development. These were the ones included in the qualitative synthesis.

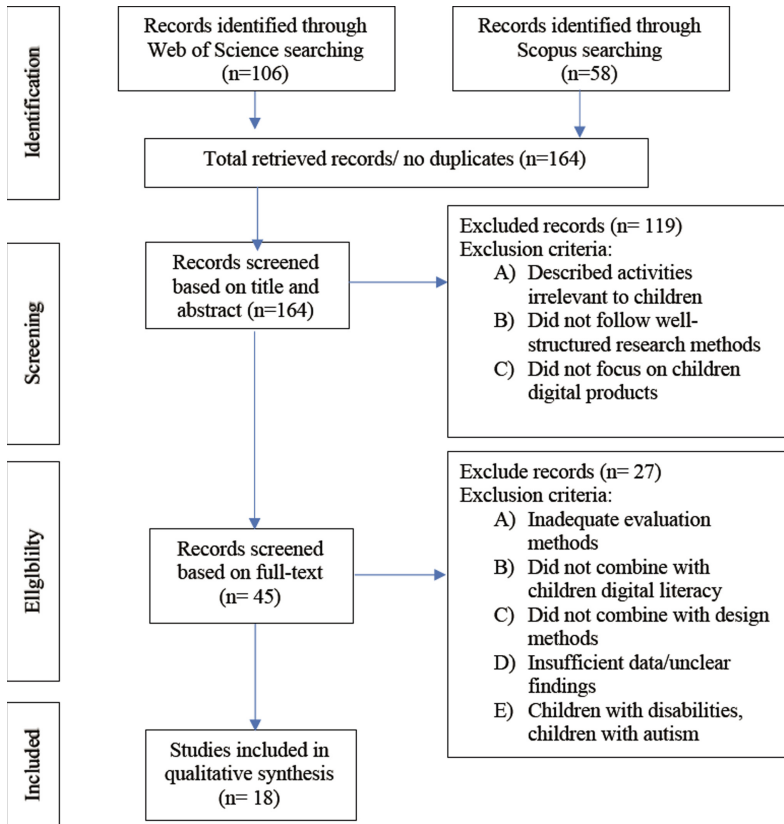


Fig. 1. Flowchart for article selection process

4 Discussion

Since the mid-1990s, digital researchers have developed a user-centric approach, where children are more challenging than adults. Over time, researchers have developed and implemented methods and activities that allow children to participate in the design process, from determining needs to assessing technology [6].

Studies include recent research developments that describe how the views and assumptions about children and interaction design were constructed, and how children influenced the design process and the interaction design regarding how to impact children's digital literacy. To better discuss children's involvement in the design process, the review on this issue with examples of studies and an analysis of relevant interaction design for children's perspectives and strategies are provided below.

Literature prior to the 1990s discussed children informing the design process, primarily as users for observation or as testers of users. If a design team is designing for children, it should allow them to test before it is released to the market. Observing children's performance during the use of product prototypes or competing products can supply feedback on their design and provide an understanding of how technology can help children and better cater for their needs, capabilities and preferences. Numerous researchers have focused on observing how digital products affect children's skills and ways of learning [6]. For example, the study by Gennari and colleagues [7] evaluated children's participation in game design and statistically analysed children's emotions in the game design experience. It shows that children's design activities from game design documentation to prototype release, with the help of expert designers, empower children to improve their game design performance. Promoting children's reflection on their products through expert feedback and peer feedback, and using collaborative learning strategies or group discussions during and across tasks, shows that engaging children can trigger more positive emotions than negative emotions. A similar study by Hamari and colleagues [8] showed that engagement in game-based learning has positive effects on students' perceived learning. The apps provide a novel way of storytelling for children. Research in this area includes authoring stories based on role manipulation, storytelling in different forms of collaboration (face-to-face and remote), and storytelling using mobile devices that capture relevant content. Based on the above research, the young learner can become immersed in learning through greater interaction design. The interactive features can stimulate children's curiosity and keep them motivated. Although this type of participation is advantageous, children's participation does not affect the current design and can only be iteratively improved, because repair issues found during testing can make the design too expensive. The design decision for this method still depends on the adult, and no child's voice can be provided during the design process.

Until the 1990s, children were not considered as design participants who could offer design directions or prompt new projects [9]. With the development of prototypes and design ideas, if a design team has questions about the progress of the design, they can work with children who can provide their ideas. Children can express their opinions through focus groups, personal interviews or written questionnaires. Hourcade (2015) argued that before design begins, children can share ideas and interests, and it is necessary to carry out activities to understand children who may use the technology and its background. Key stakeholders (e.g., parents, teachers) can often provide useful information to the team before

directly working with the children. Often, activities include observing and gathering ideas from a group of children. Understanding and observing children's thoughts or interests from the beginning of a project can make its design more targeted. However, there are not enough studies to show that children can make progress in improving their digital literacy when being used purely to provide information.

Since 2002, researchers have begun to focus on how to include children as design partners in the design process. When children participate in the design process as design partners, they become part of the design team. Children can be equal partners in promoting design development and implementing decisions [6]. In this partnership, design ideas come from collaboration between adults and children. The advantage of children joining as design partners is that they will provide more information during the design process, which may lead to technology that can better meet children's own needs, interests and abilities. Studies have shown that including children in the design process is not only conducive to the development of a design but that participatory design can also be used as a means of children's cognitive development [10]. It can also be used as a tool for capacity development by promoting critical thinking in children [11] and have a beneficial impact on children involved throughout the design process [12]. Including children on the team is not only about letting them express their thoughts and opinions, so that adults can better understand the cultural differences between generations; it can also develop children's ability to analyse and solve problems. Collaborative design thinking creates the best way for children to collaborate, allowing them to explore and define problems [13]. The study by Yarosh and colleagues [14] used a participatory design study to support child wellbeing. In teaching the invention process, children's ideas and prototypes reveal how they understand gratitude, mindfulness and problem-solving, such as preventing making wrong decisions and finding alternative solutions. When considering game design interventions on design skills for young children, Kalmpourtzis [15] claimed children could brainstorm and collectively synthesise their proposals to create joint game proposals. Allsop (2016) used mind maps and videos of group discussions to record children's thinking processes when making computer games. Participatory design is beneficial to children involved in the design process and can be used as a method of cognitive development. The process by which children design and change the games that provide this experience can address issues that both consider children's values and help them build an understanding of broader social values [16]. In a study by Qing Li [17], children claimed to experience excitement and pride when building and completing games; these positive emotions can help long-term memory and enhance creative problem-solving ability. In addition to problem-solving skills, the ability to tell and create stories is also a popular theme in children's digital literacy. Storytelling is a teaching method suitable for children. According to Hourcade (2015), "If you put facts together in one story, it is easier to remember them than in lists". Interactive technology plays an essential role in storytelling. It helps children develop communication skills, express themselves, and develop

their imagination by allowing them to store and copy, share, and edit stories. In a study by Robertson and Good [18], a virtual environment created using a game engine enabled children to participate in stories in the form of characters, allowing them to tell stories in a new way that inspired children to program. Similarly, recent research by Aliagas and colleagues (2017) showed that interactive elements increase children’s autonomy, making them co-authors or storytellers of story creation. Interactive elements can trigger a child’s response to digital text, help them create a new story, or help stories emotionally resonate with them.

Challenges are involved in making children a design partner, and it takes time to build a design team because most children do not immediately become inventors or designers. They need time to build confidence and understand what they should do in design activities [19]. Another challenge is to include children in the design team’s location. Usually, schools are the best place for design activities, but the authority of teachers will also, to some extent, help children to challenge adult opinions and cooperate in equal part [6].

5 Conclusion

In the field of interaction design, ensuring the user’s needs and focusing on the user’s capabilities and preferences are at the core of the design process. Children who participate as design partners can positively impact the development of design while also improve children’s digital literacy. Because the design process needs to consider children’s digital literacy—that is, the skills and abilities that young children need to use technology, as well as their perceptions of technology use. In comparison with the traditional views of literacy, this new form of literacy emphasises children’s ability to understand and create multimodal digital texts in order to communicate with texts or others. Young children are able to use multimodal cues to understand meaning in the context of digital text. Such multimodal cues include pictures, symbols, sounds, images, and gestures, and the process of interaction design is to use them in the design of touchscreens such as mobile tablets and phones. In addition to focusing on the skills and abilities children need to use technology, there is a need to focus on children’s perceptions of technology use. Specifically, much research has focused on how to develop children’s observations and insights into “critical thinking” through interactive design. For example, teaching children the boundaries between advertising and product content as soon as they can distinguish between the two can help children develop critical thinking skills to differentiate between media and messages as they grow up. Designers want to make the experience of “failing” or “making mistakes” more interesting for children in the design of digital products. The concept of “fun failure experience” can help children build a quality of resilience and bravery. By including children in the design process and extending the goal from digital product design to digital literacy development, children can move beyond the design process and prepare for future challenges.

The majority of the reviewed studies revealed three common ways in which children are included in the interaction design process and influence design decisions. Usually, they are involved in the early stage of the design as a provider of design intent and as a tester for product use after the product is completed. But since 2000, there has been a trend to focus on the development of children's digital literacy, and that they are not just consumers of technology, but also creators. The role of children as creators of technology not only helps with design decisions, but also helps improve children's digital literacy. Specifically, including social function design, feedback information, and exploration of innovation need to provide opportunities to child users to express themselves. If parents are used as children's spokespersons or taking parents' needs as a benchmark for measuring family needs will not reflect the complex interaction between family members effectively. Parents and children are obviously different in motivation, goals and description of the same scene, and thereby resulting in missing information. It is very challenging for children to participate in user research activities and for children to be used as interviewees. Although the language comprehension abilities of school-age children is still at the stage of development, it is still difficult for them to understand the rhetorical devices such as abstract or metaphor. Lastly, the next step of the research is to expand the methods of children's participation in design, and to study the specific methods of how to better involve children's users in the design process.

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