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Early childhood pre-service teachers' preparation for using technology with children: a systematic literature review

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ABSTRACT

This systematic literature review examined how teacher education prepared early childhood pre-service teachers to utilise digital technology with children. After searching in relevant databases the review analysed 21 articles, most of which have been published in recent years. The findings indicate that while some educational institutions have a dedicated course about digital technology, others have integrated digital competence into existing courses. Nevertheless, the review found that there is little emphasis on how to incorporate a wide range of educational technologies. Additionally, the results revealed that most teacher education curricula do not have a strong digital focus, thus indicating a need for a greater focus on combining theoretical knowledge with practical implementation for pre-service teachers. The findings indicate that further research is required in early childhood teacher education to identify ways in which digital technologies can be integrated into a more holistic approach to facilitating young children's learning.

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Early childhood teacher education (ECTE); digital; technology; early childhood education and care (ECEC); pre-service teachers

Introduction

As technology is developing rapidly and becoming part of people's everyday lives, governments have pushed for the development of appropriate knowledge, skills and technology fluency among children. The expectation is that children will be exposed to educational technologies and resources at a young age, thus enhancing the development of digital literacy and essential skills such as problem solving, critical thinking, and computational thinking (CT). These skills are anticipated as necessary for children to become active citizens. Due to advances in the child-computer interaction field, digital technologies include a variety of choices for different ages, such as educational robotics and smart toys (Komis et al. 2021; Ling et al. 2022; Undheim 2022) and coding apps (Papadakis 2021). However, it is not simple for teachers to provide opportunities for young children to engage meaningfully with these technologies. Due to the rapid

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advancement in technologies for early childhood education and care (ECEC), there is a need for pre-service education and professional development so that teachers have relevant knowledge regarding the appropriate pedagogical approaches, strategies, and competences (Dardanou et al. 2023; McKenney and Voogt 2017; Zipke, Ingle, and Moorehead 2019).

To provide relevant teacher education, there is a need to evaluate what is currently known regarding existing courses that focus on professional digital competency. Consequently, this systematic literature review (SLR) focuses on how early childhood teacher education (ECTE) provides relevant education, experience, and knowledge with respect to the use of digital technology in ECEC institutions. As such, this review considers effective incorporation of digital technology to be more than the simple use of technology, like interactive media for communication purposes. Furthermore, this SLR focuses on how ECTE courses introduce educational technologies to pre-service teachers (EC-PSTs) to support children's learning and development, including the development of skills such as problem solving, critical thinking, and CT. Curricular requirements demand the use of educational technology in ECEC institutions, and although professional digital competence already appears as a key aspect in ECTE, there remains a need to understand how ECTE institutions prepare EC-PSTs and to understand what factors are associated with the use of a critical perspective in the integration of technology in ECEC among EC-PSTs (Masoumi 2021; Undheim and Ploog 2023). Thus, this SLR goes beyond the techno-positive discourse that tends to surround policy documents (McGarr and Gavaldon 2018) to understand what may or may not influences EC-PSTs to adopt a critical perspective on the integration of technology in ECEC. Therefore, the focus question for this literature review is: *How are EC-PSTs prepared for using digital technology with young children (0–6 years old) during ECTE?* This SLR aims to provide insight regarding how ECTE institutions have supported EC-PSTs to gain understanding about incorporating different educational technologies into their work with children, as emphasised by several researchers (Komis et al. 2021; Ling et al. 2022; Papadakis 2021). Our research questions are as follows:

- What are the approaches used in ECTE to incorporate digital technology for its use with children?
- What are the outcomes and implications for ECTE described in the analysed articles?

To the best of our knowledge, there have been few if any SLRs with this aim.

Related work

Educational technologies, CT and programming in early childhood have recently gained considerable attention. For example, Macrides, Miliou, and Angeli (2022) presented different possibilities for the introduction of programming in ECEC and its integration into the curriculum but highlighted that more research is required before programming can be fully integrated into curricula. They also mentioned that ECTE programs should support the EC-PSTs' competences in introducing programming in ECEC. Bati (2022) described a plethora of plugged and unplugged tools for programming and CT, and they analysed the different factors that may influence

learning, such as age and gender; however, they did not include research on teacher education. In similar contexts, McCormick and Hall (2022) stated that it remains unclear how to design CT experiences for children and when it is suitable from a developmental standpoint to include more advanced components in the curriculum. Robotics activities are one approach to introduce CT in ECEC, but there is a lack of low-cost open-source robots that can be easily adopted by teachers (Bakala et al. 2021). The impact of coding apps to support young children's (under the age of 7) CT and computational fluency was examined by Papadakis (2021), who conducted a literature review of 21 empirical articles examining the use of four coding apps. In one of these studies, the teachers' opinions regarding the use of *ScratchJr* were discussed (Strawhacker, Lee, and Bers 2018); they found that most teachers had a favourable attitude towards its implementation in the classroom regardless of their teaching style.

In their SLR on technology education in ECEC, Eliasson, Peterson, and Lantz-Andersson (2022) examined both ECEC teachers' and EC-PSTs' perceptions and their use of technology with children. They found that the teachers seldom talked about the technology with the children during digital activities and highlighted the importance of a 'shared content-specific language' when using digital technology. According to their findings, technology education is an emerging field and confirms that it is crucial to improve young children's technology integration.

Starkey (2020) identified three types of digital competence – i.e. *generic digital competence*, *digital teaching competence* and the emerging aspect of *professional digital competence* – in the areas of EC-PST, teacher educators and teacher education programs. Starkey highlighted the need for future research to examine the latter regarding how EC-PSTs are prepared for their professional work as teachers in a digitally infused educational environment. Schina, Esteve-González, and Usart (2021) conducted a review regarding teacher education courses in educational robotics. In their review, they discussed aspects such as the duration of the courses and the implemented pedagogies. Their results show that of the 38 analysed studies, only three had courses solely for EC-PST, indicating the need for further research on this topic.

Integrating technology into ECEC is not an easy process and requires teachers to gain a complex network of knowledge and competencies. However, the continuous changes in technologies and the constantly evolving demand for digitally competent citizens require an equally responsive educational system for EC-PST. Therefore, due the lack of research in this aspect, the aim of our SLR is to explore how EC-PSTs are prepared to use digital technology with young children (0–6 years old) during ECTE.

Material and method

This study followed the SLR methodology proposed by Kitchenham (2004). The authors discussed each step's actions, including the initial steps of developing the protocol, the formulation of the research questions, data collection, inclusion and exclusion criteria, and analysis. Narrative synthesis and thematic analysis were performed (Grant and Booth 2009). The protocol was based on Wang and Tahir (2020) and had the following aims: 1) to maximise the literature coverage; 2) to identify and include the related work

that can be classified as a study; and 3) to collect and synthesise meaningful data from the sources related to the defined research questions.

Data collection

The keywords and database searches were selected based on what was used in relevant reviews on similar topics in recent years.

The following search string was used: '(digital OR technology OR ICT) AND (pre-service teach* OR initial teach*) AND educat*'. The Scopus, Web of Science and ERIC databases were searched from 2012 to October 2022, as these databases provide extensive coverage of relevant journals. Additional searches were performed in Google Scholar, and a snowballing approach was used to identify additional papers. Different syntax and semantics were used to match the databases' respective search schemes. A total of 6.656 documents were collected, and after removing duplicates, 5.526 remained (Figure 1). The first author screened the titles, keywords and abstracts, while the second author performed a quality check by scanning random documents using Zotero. A total of 351 relevant articles were then uploaded to Rayyan; the first and second authors read the articles and determined their eligibility. Then, the first, second and fourth authors had meetings to determine which articles were ultimately included.

Inclusion, exclusion and quality criteria

To identify as many articles as possible for this SLR, we used the following criteria. In most countries, ECEC includes children aged 0–6 years old, but some countries (e.g. the U.S., Australia) include children aged 0–8 years old (Kamerman 2000; OECD 2001). Therefore, we have included some articles focusing on primary school. Ultimately, 21 articles met the inclusion criteria and were included in our SLR.

More specifically, the included articles were required to be rigorous, credible and relevant to this SLR's context.

The inclusion criteria were as follows:

- Focus on ECTE and EC-PST
- Include pedagogical use of digital technology with children aged 0-8
- Empirical research
- Clearly stated objectives and adequately described context
- Appropriate research design to address the aims of the study
- Rigorously performed data collection and analysis
- Findings that were clearly stated
- Clear contribution to the field

The exclusion criteria were as follows:

- Workshop article, poster, work in progress, book or book chapter
- Focus only on PSTs' own development of digital skills
- Published in a non-peer-reviewed journal or venue

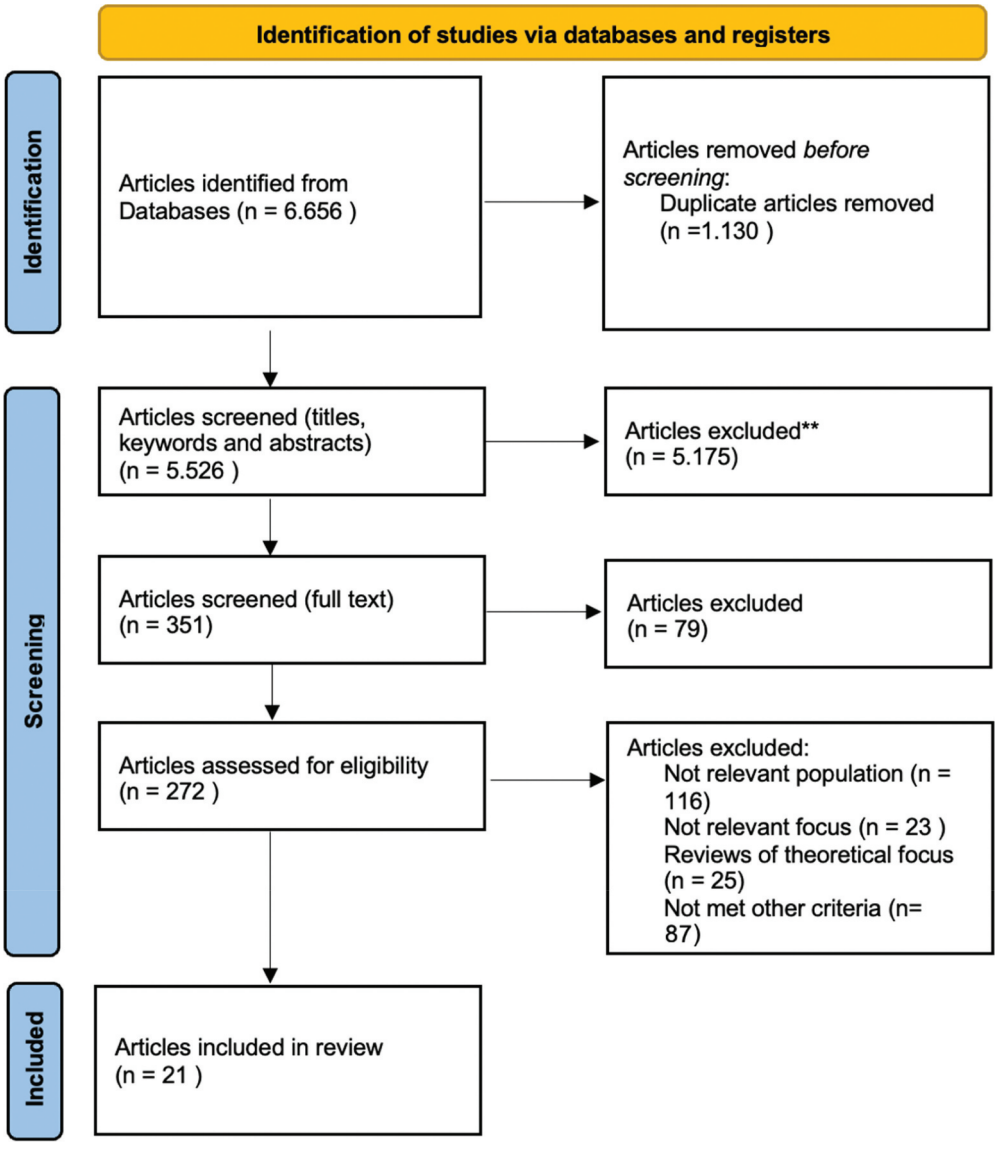

Figure 1. PRISMA 2020 flow diagram showing the process for the selection of the final included articles.

- Written in another language than English
- Not published between 2012 and 2022
- Literature review

Data extraction

The included articles were coded based on specific areas of focus and the information included in a shared Excel file. The synthesis of the results was performed using thematic

analysis (Braun and Clarke 2021), and based on our research questions, different categories emerged.

Results

General findings

The 21 included articles were published from 2012 to 2022; fifteen of them were published during the past four years (Figure 2 right). All included articles focused on PST: thirteen articles involved only EC, four articles involved EC and primary, three articles involved primary/elementary, and one article involved EC to 6th grade.

The research originated in several countries (Figure 2 left). Many of these countries have policies in which ECEC is seen as preparing children for school (Bennett 2005). These articles were set predominantly in Turkey and the U.S. Five articles focused on teacher education for primary grades and took a school learning approach. Of the remaining articles, many investigated PSTs' own learning about using technologies and not about how they would integrate these technologies into their work with children. Only three articles considered aspects of integrating technologies into ECEC with a social policy pedagogy approach by discussing how technologies could be connected to children's creativity; one of these studies was conducted in China (Dong and Xu 2021), one in Hong Kong (Hu and Yelland 2017), and the third study in Slovenia (Starčič et al. 2016).

With regard to the research design used in the articles, eleven used mixed methods, six used a qualitative design, and three used a quantitative design. Thirteen articles mentioned information relevant to the approach used for course instruction. Five articles (Eutsler 2022; Hsu 2012; Masoumi 2021; Oakley 2020; Tokmak and Ozgelen 2013) used the TPACK framework (Mishra and Koehler 2006), while the others used something different; for example, Alqahtani et al. (2022) used the first principles of instruction (FPI) (Merrill 2012).

RQ1: What are the approaches used in ECTE to incorporate digital technology for its use with children?

The ECTE institutions incorporated digital technology into their programs, either in specific technology courses or into other courses. This is relevant for determining whether

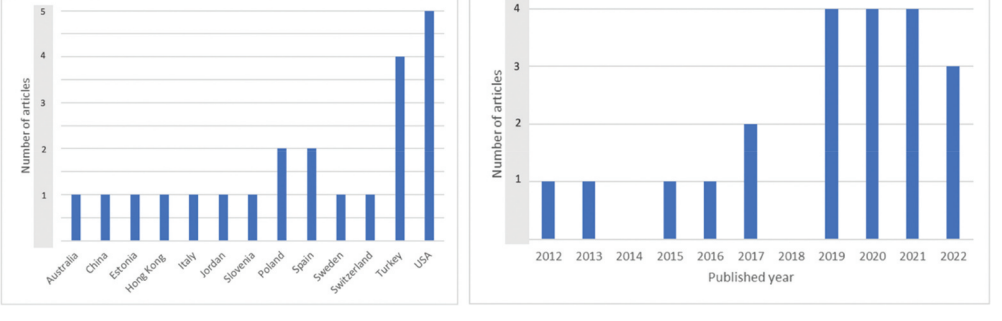

Figure 2. Number of articles published per country (left) and number of articles published per year (right).

and how PSTs are being prepared for their work as ECEC teachers. Three of the included articles did not investigate a specific course (Dong and Xu 2021; Masoumi 2021; Sillat, Kollom, and Tammets 2017).

Specific technology courses

Ten of the articles focused on EC-PSTs' and primary PSTs' learning in technology courses. In three articles, the courses emphasised one aspect of digital technology. Starčič et al. (2016) described a course about educational technology focusing on digital stories. The course consisted of instructional and learning activities in which the EC and primary PSTs designed a lesson plan in which children created a digital story. *PowerPoint* and *MovieMaker* were used for production and storage, as well as mobile phones, scanners, and cameras. The PSTs were required to observe and write reflections about implementing digital technology in schools during teaching practicums. Gabriele et al. (2019) presented an eight-week programming course. During the first three weeks, the EC and primary PSTs were introduced to the main coding concepts by using *Scratch 2.0* and how to design educational apps that could be applied in school contexts. During the following five weeks, the PSTs worked in groups to design and implement their apps. In Tokmak and Ozgelen's (2013) study, two TPACK-based courses focusing on computer games were described. In the first course, the EC-PSTs selected computer games and prepared lesson plans to teach a topic; in the second course, they redesigned these computer games and prepared lesson plans. The duration of courses described by Starčič et al. (2016) and Tokmak and Ozgelen (2013) is not specified.

The courses in seven other articles seemed to have broader aims. Botturi (2019) presented an introductory course on digital media literacy for EC and primary PST. The course consisted of twelve two-hour sessions on accessing information, creating content, analysing media, behaviour and ethics, and social action. The course consisted of lectures regarding why these topics were important, hands-on experimentation, key concepts from the literature, and discussion to foster reflection. Avsec and Sajdera's (2019) focus was on technology and engineering. In their study, through theoretical and practical lessons, EC-PSTs were given information about several aspects of technology and engineering in ECEC, for example, an introduction to the world of design and technology, creative technical educational activities in ECEC, and young children's manipulative and constructive play. Hsu (2012) described three technology courses for primary PSTs; each course lasted four months. The first course was for technology productivity skills, focusing on software programs and applications. The second was about educational technology, and the third was about practical integration of technology. All three courses focused on exploring, planning and integrating technology to support children's learning.

While some of the articles provide rich details regarding the content of the courses, as presented above, others described the courses briefly without any information regarding the content (Alelaimat, Ihmeideh, and Alkhawaldeh 2020; Hu and Yelland 2017; Kulaksız and Toran 2022; Romero-Tena et al. 2020). In Hu and Yelland (2017), the focus was EC-PSTs' use of digital technology during their teaching practicum. Prior to the practicum, the PSTs had finished a course regarding the use of digital technology, but no information about the content of this course was provided. Kulaksız and Toran (2022) presented findings from an eleven-week remote instructional technology course on planning, preparation, collaborative activities and projects and the PSTs' reflections. Alelaimat,

Ihmeideh, and Alkhawaldeh (2020) list three technology courses, all designed to provide EC-PSTs with skills to integrate technology into teaching practices for 3–6-year-olds. Romero-Tena et al. (2020) presented a training intervention in and with technology in a course for EC-PSTs that lasted one semester.

Summarising, the content of the courses described in these ten articles is mostly a combination of theoretical lectures and practical hands-on workshop-inspired sessions and reflections. The duration of the courses varied from eight weeks to one semester. In five of the articles, the PSTs were required to design relevant activities, lesson plans, or other instructional materials for children during the courses (Gabriele et al. 2019; Hsu 2012; Kulaksız and Toran 2022; Starčič et al. 2016; Tokmak and Ozgelen 2013). However, PSTs only implemented activities with children in two of the articles (Hsu 2012; Starčič et al. 2016).

Technology incorporated into other courses

In seven articles, digital technology was incorporated into other ECTE courses. Few details are included about whether the content was introduced across the whole course or just parts of it.

Two articles describe early literacy courses. Eutsler's (2022) study was on literacy apps. During five 80-minute hands-on iPad workshops over two months, 28 apps to support literacy learning were introduced to EC and primary PST. The course was organised as workshops trying various apps and designing learning activities to improve literacy skills. In the first two workshops, the instructor modelled learning activities and how to use various apps. In the following three workshops, the PSTs designed learning activities with the apps. In Oakley's (2020) study, EC and primary PST created a digital storybook using iPads or PCs and *PowerPoint* as part of an assignment; they used it on their first practicum to teach literacy concepts to 4–8-year-olds.

Three articles investigated EC science education courses. Yilmaz and Siğirtmaç (2020) described a course on digital stories in EC science education. The course consisted of four training sessions on various themes like benefits and limitations for using technology-assisted instruction, hands-on use of digital technology, such as creating digital stories in *Photo Story-3*, and a thirteen-day practicum in ECEC institutions (once every week for 13 weeks). During the practicum, the EC-PSTs prepared daily plans. Çiftçi, Topçu, and Foulk (2022) described a 14-week course on basic concepts of science and STEM and how to teach them in ECEC. During the last nine weeks, EC-PSTs worked in groups and prepared lesson plans focusing on STEM activities by combining science, mathematics, technology, and engineering. The course in Kim et al. (2015) was designed to prepare primary PSTs to integrate hands-on learning with STEM instruction. Robotics-related activities were integrated into the course curriculum as one of the learning modules, which lasted three weeks. The first week included a lecture on robotics and educational applications and introduced the robot kits *My Robot Time* and *Robo Robo*, with PSTs having time to explore them. In the second week, the PSTs learned how to program and build their own robots. In the third week, they designed instructional strategies and developed lesson plans with robotics activities for K-5 classrooms.

Two articles on the use of robots were connected to mathematics education courses. Alqahtani et al. (2022) described how primary PSTs were introduced to robots. For one 90-minute session, the PSTs were introduced to geometry and arithmetic activities using

robots and CT. Three weeks later, some of the PSTs designed and implemented robotics activities at a primary school with first-grade pupils. They used Bee-Bots, Blue-Bots and an app on iPads. Blue-Bots were also used in Schina et al. (2021) during an EC mathematical course. For three 2-hour sessions, the EC-PSTs were introduced to various educational robots, explored and learned how to use them in ECEC and created lesson plans.

Finally, Aldemir, Barreto, and Kermani (2019) presented a course called 'Play and creative art' on planning and delivering play-based and developmentally appropriate experiences with digital technology in ECEC. First, the EC-PSTs designed activities in which they integrated tablets and relevant apps for young children in ECEC. Then, they implemented two of their lesson plans during teaching practicums. No further information about the content of the course was provided.

As was the case with the dedicated technology courses, the content in these seven articles was mostly delivered through a combination of theoretical lectures and practical hands-on, workshop-inspired sessions and reflections. As with the previous set of articles, the PSTs were required to design relevant activities or lesson plans with children. The courses were about integrating robots (Alqahtani et al. 2022; Kim et al. 2015; Schina, Esteve-González, and Usart 2021), apps and tablets (Aldemir, Barreto, and Kermani 2019; Eutsler 2022), and digital stories (Oakley 2020; Yilmaz and Siğirtmaç 2020). However, even though there is a greater emphasis on preparing and designing activities with children, compared to the previous set of articles, the PSTs only implemented activities with children in four articles (Alqahtani et al. 2022; Kim et al. 2015; Oakley 2020; Yilmaz and Siğirtmaç 2020). The duration of the courses was shorter than in the technology courses, from three weeks to fourteen weeks.

RQ2: What are the outcomes and implications for ECTE described in the included articles?

Attitudes and perceptions among PSTs towards using technology with children

Many of the included articles focused on PSTs' attitudes towards using technology with children and found that engaging PSTs in preparation courses improved not only PSTs' attitudes and perceptions but also their intentions to use technology in their future work.

Of the articles investigating a specific technology course, several showed that PSTs had limited knowledge or low self-efficacy before the course. The case study by Botturi (2019) demonstrated that even a brief course could have an impact on PSTs incorporating digital media literacy into their work. In this study, PSTs' self-efficacy increased. Starčič et al. (2016) reported that by the end of the course, the PSTs felt prepared to integrate digital story making and had developed positive opinions on the use of technology in teaching and learning. Similar results were reported by Romero-Tena et al. (2020), who observed significant improvement in PSTs' self-perception of digital technology before and after a technology course. Alelaimat, Ihmeideh, and Alkhawaldeh (2020) showed that PSTs had a positive attitude towards integrating technology and digital media into their future work, although their satisfaction level with their preparation for such activities was less favourable.

One study reported that PSTs showed negative attitudes towards technology prior to the course (Kulaksız and Toran 2022). Despite their initial negative attitudes, their engagement in both self- and group-learning activities during the course resulted in positive changes in

their attitudes, knowledge, and skills about the use of technology in ECEC. This finding indicated that PSTs could learn on their own, design projects collectively, mentor their peers, and transfer knowledge and skills to different contexts at the end of the course.

Of the articles investigating ECTE courses in which technology was included, EC-PSTs' attitudes towards and knowledge of technology improved during the courses. Kim et al. (2015) found that PSTs' emotional engagement with STEM significantly improved, which in turn influenced their behavioural and cognitive engagement in planning STEM lessons. Similarly, Schina et al. (2021) showed that PSTs' attitudes, acceptance, and perceptions towards the use of technology as well as their self-efficacy for using educational robots improved significantly. Alqahtani et al. (2022) also found that engaging PSTs in professional learning about robots and having them implement robots in teaching practice improved PSTs' attitudes and their intentions for using technology in their future work. In another study (Oakley 2020), the majority of PSTs reported being actively involved in making digital storybooks and using them during their practicum. This supported them in increasing their technological, pedagogical, and content knowledge for teaching literacy in the early years. Yilmaz and Siğirtmaç (2020) found that PSTs after the teacher education course improved their awareness of the use of technology, achieved greater competence in using digital stories and improved their self-efficacy, which positively influenced their motivation to use technology in their teaching.

In addition, Sillat, Kollom, and Tammets (2017) found that EC-PST reported that teacher education provided them with fresh knowledge, thoughts, ideas, and energy, expanded their horizons, and encouraged them to explore diverse technologies. This study focused not on a specific course but on ECTE in general. The PSTs stated that a variety of software and technological solutions could be used as a teaching tool, as a means for making learning materials, and as an information-searching agent while working with young children. Accordingly, they concluded that using technology is not necessarily dependent on digital competencies rather than on teachers' leadership and self-management skills.

Recommendations and implications

Many articles have discussed specific recommendations or outcomes regarding PSTs preparation for technology integration in ECEC. Several articles focusing on a specific technology course emphasised the inclusion of both pedagogical and technology knowledge. In the study by Alelaimat, Ihmeideh, and Alkhawaldeh (2020), PSTs reported a lack of knowledge regarding their needs for learning about technology, how to integrate technology in ECEC and how to engage children in activities related to technology.

Similarly, Hu and Yelland (2017) highlighted that pedagogical competence for using technology among EC-PSTs needed to be improved in ECTE to meet local contexts. The context of ECEC may vary according to location, and there is a need to create and adapt local guidelines and exemplary pedagogical practices about technology integration into ECEC. Hsu (2012) suggests that professional development activities regarding technology integration should be offered regularly to PSTs to keep them updated on new technology. Moreover, Hsu recommends that all departments/faculties connected to ECTE collaborate to develop technology-integrated teacher education.

Avsec and Sajdera (2019) recommended that lessons about technology are better achieved through peer instruction and interactions during group work. In addition, pedagogical approaches such as experimentation, design-based work,

project-based work, and inquiry-based learning can be used to promote higher cognitive levels of achievement and creative performance. Technology courses need to provide EC-PSTs with opportunities to observe the effects of technology so that they can think critically and make appropriate decisions about their future work with children. However, Tokmak and Ozgelen (2013) found that choosing educational computer games is a complicated and difficult process; most of the computer games chosen by the PSTs, even those intended to be educational games designed for young children, were not suitable for the learning activities they planned to use them for.

Several articles focusing on technology integrated into other ECTE courses highlighted the need for sufficient time to experiment with the technology and try out activities. For example, Eutsler (2022) emphasised the value of using a scaffolded approach. From this perspective, it is crucial to create space and time during ECTE courses to support PSTs experimenting with and learning how technology can be used in their future work with children by providing them a safe place where they can try, fail, and enhance their technological and pedagogical skills. Hands-on technology experiences were also appreciated by the PSTs because they had the opportunity to explore tools and imagine them in effective use in their teaching (Eutsler 2022). In addition, Schina et al. (2021) provided some recommendations for future ECTE courses, such as adding supplementary sessions to promote EC-PSTs' acceptance, self-efficacy and perceptions of technology integration. This would give the PSTs extra time to experiment with resources and teaching materials, so they could feel more comfortable and confident, which could help them enjoy the learning process at their own pace. They also recommend that PSTs write a journal about their learning experiences. Aldemir, Barreto, and Kermani (2019) revealed that adapting a new teaching tool such as tablets and apps required adequate time and repeated practice during practicums. They also reported that to meaningfully engage young children with technology, some of the PSTs even needed support to understand and implement various pedagogical strategies. The same suggestion is offered by Alqahtani et al. (2022), indicating that providing a variety of opportunities for PSTs to explore, think about, and experience technology in their practicum can promote the integration of technology in their future work.

Çiftçi, Topçu, and Foulk (2022) found that making interdisciplinary associations (e.g. 'integrative STEM inclusion', 'multisubject inclusion' and 'STEM inclusion') in the process of developing lesson plans was a difficult task for some PSTs. Therefore, they suggested that to develop and implement lesson plans, PSTs need to engage in more example activities.

Oakley (2020) recognised that some PSTs faced challenges when using technology in their practicums. This suggests that PSTs need opportunities to discuss challenges and concerns with their supervising teachers. The PSTs' reflections after the activities should focus on both what worked as planned and what went wrong, what knowledge and skills were applied and what the limitation was. This method would possibly help PSTs focus on what they need to learn and consequently strengthen their knowledge and skills regarding digital technology.

In Masoumi's (2021) study, PSTs reported that they were not adequately prepared to integrate technology into their future educational practice. In contrast, the teacher educators stated that they had provided a variety of activities to prepare PST to integrate

technology. This highlights some important challenges for technology integration practice. ECTE may provide sufficient experience, but some PSTs do not attend or actively engage when the activities are not compulsory.

Several of the articles recommend that ECTE create a stronger curriculum consisting of knowledge about the technology and provide the EC-PSTs with opportunities to use technology with children during practicums. This will give future EC teachers the opportunity to be more confident with the integration of technology into ECEC. Masoumi (2021) suggests offering a stand-alone course – or at least part of a course – on integration technology to give PSTs a better understanding of why, what and how technology can be integrated into their future practices.

According to Dong and Xu (2021), the first step for teacher education courses is to identify the PSTs' level of digital competence. Identifying their initial knowledge and experience can help provide an appropriate level of training that can meet PSTs' different learning needs. The second step is to offer a comprehensive analysis of the effect of digital technology on young children's learning and development. The third and last step is focusing on enhancing PSTs' pedagogical knowledge and skills in technology integration in their future educational practices. Advanced pedagogical knowledge and skills in technology integration would give future teachers the ability to explore the broad range of potential opportunities that technology can offer for young children's learning and development.

Discussion

This SLR aims to expand and deepen our understanding of how EC-PSTs are prepared during their education to use digital technology in their future work with children. After searching relevant databases and applying the inclusion and exclusion criteria, 21 articles were analysed. The findings indicate the approaches used to incorporate digital technology in ECTE, the PSTs' attitudes and perceptions towards using technology with children and recommendations or outcomes regarding their preparation for technology integration in ECEC.

The results show that there has been an increase in publications on this topic in recent years, as the majority of the included articles were published after 2019. This is expected, given the focus on digital technology in society (European Commission 2020; OECD 2023) and the increased use of digital technology in ECEC (Dardanou et al. 2023; Undheim 2022), at least in Western countries where most research has been undertaken.

In only three articles was the focus on using robots and one on Scratch. This is unexpected, as many articles have focused on the implementation of these technologies in practice (Bati 2022; McCormick and Hall 2022; Papadakis 2021). A possible explanation could be the lack of low-cost open source robots focusing on ECE (Bakala et al. 2021) that might have made it difficult for some to integrate them into their courses. Given the lack of focus in the articles on using a range of educational technologies that already exist, it is unclear how the PSTs will be informed about new technologies and their possibilities. Furthermore, there are gaps in the CT experience designs, the scope of the CT activities and the CT tool research and development in ECEC (McCormick and Hall 2022). The success of integrating digital technology depends less on the availability of technology and more on teachers' competence and attitudes to make appropriate choices for work

with young children (Dardanou et al. 2023; Undheim 2022). Teachers need to evaluate the didactic and pedagogical value of technology to facilitate its integration into ECEC (Alvestad and Jernes 2014; Erstad, Kjällander, and Järvelä 2021). Research has shown that preparing EC-PSTs for their roles as teachers is essential (Alelaimat, Ihmeideh, and Alkhawaldeh 2020; Masoumi 2021; McKenney and Voogt 2017; Spiteri and Chang Rundgren 2020; Zipke, Ingle, and Moorehead 2019).

Schina et al. (2021) found that the use of educational robotics is seldom based on theory. However, in formal education settings, such as university courses, theory has an important contribution. In many articles, the PSTs were asked to create relevant activities and/or lesson plans or other kinds of materials that used technology, although only a few articles let the PSTs try these with children. This highlights the need for a stronger digital focus in the curriculum and more courses which combine theory with in-practice implementation for PST. This is in line with relevant research in STEM teacher professional development programs where three main themes of 'learning by design', 'scaffolding authentic experiences', and 'collaborating with peers' were the ways that were most frequently reported; more recently, 'reflecting on practice' has also been promoted (Huang et al. 2022). In addition, only three articles (Dong and Xu 2021; Hu and Yelland 2017; Starčič et al. 2016) appear to have a social policy pedagogy approach (Bennett 2005), discussing how technologies could be connected to children's creativity. More research in ECTE can consider how digital technologies could be integrated into a more holistic approach to young children's possibilities to learn.

Most of the articles used mixed methods, and only four used qualitative methods. Materials produced during the course were also a commonly used data collection method, probably because these data are easy to collect while also giving rich insights, especially about the PSTs' reflections and anyways produced from the participants during the course.

Generally, PSTs' attitudes towards and knowledge of technology improve during courses by broadening their horizon and encouraging them to test various technologies (e.g. Alqahtani et al. 2022; Kim et al. 2015; Oakley 2020; Schina, Esteve-González, and Usart 2021; Sillat, Kollom, and Tammets 2017; Yilmaz and Siğirtmaç 2020). However, the articles mostly describe what was done without critically evaluating the results. As was found by Undheim (2022), in her literature review about children and teachers engaging with technology, there is also a need in ECTE to incorporate more viewpoints in the discussion.

Our SLR found that a stand-alone course on digital technology, or at least a portion of one, was suggested by the PSTs as a way to help them understand why, what, and how technologies may be used in ECEC (Masoumi 2021). In Aldemir, Barreto, and Kermani (2019), the PSTs were concerned with finding different applications' appropriateness for the developmental stage of children. One challenge with educational technology is choosing tools and practices that are developmentally appropriate (Hamilton et al. 2020; Pugnali, Sullivan, and Bers 2017).

This SLR has some limitations. First, it includes articles from three databases, the selection of keywords used for the search, the inclusion of articles in English, and not including grey literature. Therefore, we cannot claim that all existing publications on the topic are included. Future research can be in different lines, using different keywords, databases or searches in specific venues. Based on the scope of this review, we analysed the selected articles using specific areas of focus. Having a different approach in the articles' analysis might have had

different outcomes. Future articles can focus on how in-service teachers use technology in ECEC and what was considered valuable or adequate for their preparation in ECTE.

Conclusion

In this paper, we present a comprehensive analysis of 21 articles, following the SLR process, with a focus on how EC-PSTs are prepared concerning the use of digital technology with children. The results demonstrate that certain ECTE institutions offer dedicated courses on digital technology, while others have integrated this competence within existing courses. However, there is a limited emphasis on utilising a diverse array of educational technologies. Notably, most teacher education curricula need more emphasis on merging theoretical knowledge with practical implementation for PSTs. The findings highlight the necessity for further research in ECTE to identify effective strategies for integrating digital technologies into a more comprehensive approach to fostering young children's learning.

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