



# Teachers' Challenges in ICT Integration for Early Childhood Education: A Systematic Literature Review

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## Abstract

Teachers still encounter obstacles when trying to include ICT into early childhood education, despite the growing importance of this practice in promoting digital literacy and age-appropriate learning. Researchers in this study want to learn more about current trends in the field and the obstacles that educators have when trying to include technology into their work with young children. Using the criteria outlined in PRISMA 2020, a systematic literature review was performed using 23 journal articles indexed by Scopus and published between 2016 and 2025. Studies that focused on teachers' experiences, both empirically and conceptually, made up the unit of analysis. Data were analyzed using thematic synthesis and bibliometric mapping to identify patterns and trends. The findings reveal growing research interest in ICT-ECE, alongside persistent barriers related to infrastructure, limited professional development, low TPACK levels, and difficulties aligning ICT with play-based pedagogy. These results imply the need for context-sensitive ICT integration models and sustained teacher capacity building to inform policy and practice.

**Keywords:** *ICT Integration; Teacher Challenges; Learning Technology; Early Childhood Education.*

## Article Info

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## 1. INTRODUCTION

Education is one area that has been profoundly affected by the rise of ICT and is now grappling with the issues posed by the Fourth Industrial Revolution and Society 5.0 (Tahlia et al., 2024). According to Hasanah et al. (2024), in order for students to be prepared for the digital revolution, it is essential that technology be fully integrated into the learning process. This will allow them to develop 21st-century skills and digital literacy from a young age. Incorporating information and communication technology (ICT) into early childhood education (ECE) has the ability to boost children's imagination, problem-solving skills, and preparedness for future academic challenges. (Hasanah et al., 2024; Kasmiasi, 2025).

The latest data shows that the penetration of digital devices and the internet in early childhood education institutions in various developing and developed countries has increased significantly between 2022 and 2025. According to a UNESCO survey (2023), more than 70% of early

childhood education institutions in Southeast Asia now have access to digital devices and the internet, enabling the implementation of ICT-based learning, despite inequalities in rural areas (UNESCO, 2023). In Indonesia, data from the Ministry of Education and Culture's Early Childhood Education Directorate (2023) shows an increase in ICT access in early childhood education from 45% in 2022 to 63% in 2025, indicating a positive trend but still showing infrastructure gaps between regions (Susanti et al., 2024).

The urgency of ICT integration in ECE lies not only in the availability of devices but also in children's ability to develop digital literacy, creativity, and social and cognitive skills (Purnamasari et al., 2023; Wijaya et al., 2025). The use of technology from an early age is believed to stimulate critical and adaptive thinking skills, which are core competencies of the 21st century (Nurhayati & Novianti, 2024; Shiddiq et al., 2024). Also, by incorporating ICT into ECE, young children may have their learning experiences adapted to their unique needs and traits via interactive and individualized lessons, which will set them up for success in later grades. (Hasanah et al., 2021; Wijaya et al., 2025).

Recent research by Yusuf & Darmasnyah (2025) shows that ICT integration in ECE not only enables the use of digital devices but also truly supports children's holistic development. Through media such as educational applications, learning videos, and interactive devices, technology has been proven to strengthen children's cognitive, social, and motor skills, including improving critical thinking, creativity, and social interaction. However, this study also highlights that these positive results are highly dependent on teacher readiness, digital infrastructure, and parental digital literacy as key factors supporting effective implementation.

Other international studies, such as the one by Plowman & McPake (2013), show that children's interaction with digital technology can result in a form of "guided interaction" that enhances children's learning independence and exploration skills. The integration of ICT in early childhood education also enables the creation of learning experiences that are more personalized, interactive, and tailored to children's developmental characteristics. Technologies such as educational applications, interactive multimedia devices, and digital storytelling have been proven to enrich children's play-learning experiences, increase engagement, and strengthen their understanding of basic concepts (Blackwell et al., 2014).

However, the implementation of technology in ECE cannot be understood narrowly as merely the provision of facilities and infrastructure. Research (Istiana & Widodo, 2023) confirms that the success of ICT integration depends on the quality of teacher training, institutional readiness, and adequate infrastructure support. In many institutions, teachers still face a gap between policy demands that encourage digitization and their digital competencies. Similar findings were reported by (Subekti et al., 2024), which showed that even though technological devices are available in ECE institutions, teachers are not yet fully capable of operating these technologies in a pedagogical context, especially when they have to adjust the use of technology to the developmental needs of early childhood. In the same context, (Ihmeideh, 2009) also emphasized that the integration of computers in ECE is greatly influenced by teachers' perceptions, infrastructure readiness, and institutional support, which are often not balanced. These obstacles show that ICT integration in ECE requires teacher readiness, which includes technical skills, pedagogical knowledge, and the ability to design meaningful and safe learning for children.

In addition to structural obstacles, professional issues such as a lack of in-service training opportunities, limited digital-based pedagogical content that is developmentally appropriate (developmentally appropriate practice/DAP), and low incentives to improve digital competence further exacerbate the gap in ICT implementation (Ertmer & Ottenbreit-Leftwich, 2014). Without strengthening teacher capacity, technology tends to be used only as an administrative tool, not as a pedagogical tool that encourages meaningful learning experiences. In Indonesia, these challenges are also evident in recent studies. An analytical study found that although some ECE teachers have good digital competencies in the dimensions of information and communication, there are significant variations in their ability to utilize digital media as part of a learning strategy that is appropriate for children's developmental needs (Mas'ud et al., 2022). Teachers are often able to access and operate devices, but are not yet fully skilled at integrating technology into interactive and meaningful play-based learning scenarios.

In this research, the incorporation of ICT into ECE is seen as a pedagogical process that positions educators as key players, going beyond their role as simple digital device users. Technological Pedagogical Content Knowledge (TPACK) is the theoretical foundation of this research. TPACK states that in order to effectively integrate ICT, one must have knowledge of both technology and pedagogy, as well as content. (Mishra & Koehler, 2006). In the context of ECE, this framework is reinforced by the principle of Developmentally Appropriate Practice (DAP), which emphasizes that the use of technology must be in line with children's developmental needs and support play-based learning (NAEYC, 2020). In addition, ICT integration is also influenced by systemic support, such as professional training, institutional policies, and the availability of digital learning resources (Ertmer & Ottenbreit-Leftwich, 2014). Based on this framework, this study departs from the analytical assumption that the challenges of ICT integration in ECE are more often caused by limitations in teachers' pedagogical capacity and institutional support than by the absence of technology itself.

This gap between the potential of ICT and the reality of its implementation confirms that the availability of devices alone is not enough. The integration of ICT in ECE must be accompanied by systemic support, namely continuous training, supportive policies, the provision of adequate infrastructure, and pedagogical approaches that are sensitive to early childhood development. These findings underlie the urgency of conducting a systematic literature review (Snyder, 2019) which aims to synthesize international evidence published between 2016 and 2025, thereby providing an up-to-date and comprehensive overview of global research trends and teachers in ICT integration in ECE. Therefore, this study is guided by three research questions:

- RQ1. What are the prevailing research trends in ICT in early childhood education over the past decade?
- RQ2. What are the challenges and obstacles faced by teachers in integrating ICT in early childhood education?

The results of this study are expected to contribute theoretically by mapping and clarifying the current situation and gaps that still exist in the literature on ICT integration in early childhood education and practically by providing information to teachers, curriculum developers, and policymakers to strengthen ICT strategies in early childhood education institutions.

## **2. METHODS**

### *Research Design*

In order to synthesize the research on the difficulties instructors encounter while incorporating ICT into early childhood education, this study adopted a Systematic Literature Review (SLR) as its research design. Because studies in this area tend to be scattered across fields including psychology, education, and environmental studies, SLR was selected as a way to integrate information in a systematic and transparent way. The PRISMA 2020 recommendations (Page et al., 2021) were adhered to throughout the review process. These standards provide a solid framework for systematically finding, screening, and selecting research. In order to systematically map research trends, educational methods, and implementation obstacles, the SLR used defined techniques. At the same time, this design facilitates a critical synthesis of findings that enables the identification of conceptual gaps and the development of recommendations that can inform future research, policy, and practice in ICT learning in early childhood education. (Donthu et al., 2021; Snyder, 2019).

### *Search Strategy*

The search for this review was conducted exclusively using the Scopus database. Scopus was chosen because of its reputation as one of the most multidisciplinary databases, covering journals in the fields of education, psychology, environmental studies, and related fields directly relevant to this study. In addition to its broad coverage, Scopus offers consistent metadata quality and export functions that support scientometric analysis, ensuring transparency and reproducibility in the review process (Falagas et al., 2008). Google Scholar, the Web of Science, PubMed, and ERIC were among

the other databases that were taken into consideration. But for this study's systematic literature search and analysis, Scopus is a relevant and methodologically acceptable source.

The decision to focus the literature search exclusively on Scopus was made deliberately to ensure consistency, quality control, and transparency in the review process. Scopus applies rigorous indexing standards and provides comprehensive coverage of high quality, peer-reviewed journals across education, technology, and social sciences, which are directly relevant to the scope of this study. Using a single, well-curated database also helped minimize duplicate records and supported a more traceable and reproducible screening process. While complementary databases such as Web of Science or ERIC may index additional relevant studies, the selected approach prioritizes depth and methodological rigor over database breadth, in line with established practices in systematic literature reviews.

The search was conducted by selecting publications between 2016 and 2025, focusing on recent developments in early childhood education and information and communication technology. Only articles published in English were considered, as this context ensures accessibility and consistency of analysis, despite the limitation of not including non-English literature. The search strategy used a combination of keywords and Boolean operators to capture a broad but precise set of studies. The main search strings were as follows (Table 1).

**Table 1. Data Sources and Search Strategy**

Databases	Scopus
Search Period	2016-2025
Keywords	“Information and Communication Technologies”, “Digital Learning”, “Early childhood Education”
Keyword Combination	TITLE-ABS-KEY ( ( "educational technology" OR ICT OR "digital learning" ) AND ( "early childhood education" OR preschool OR kindergarten ) AND teacher ) AND PUBYEAR > 2016 AND PUBYEAR < 2025 AND ( LIMIT-TO ( SUBJAREA , "COMP" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) ) AND ( LIMIT-TO ( EXACTKEYWORD , "Early Childhood Education" ) OR LIMIT-TO ( EXACTKEYWORD , "Information And Communication Technologies" ) OR LIMIT-TO ( EXACTKEYWORD , "Teachers" ) OR LIMIT-TO ( EXACTKEYWORD , "Digital-learning" ) )

Data retrieval date: December 1, 2025

To make sure it was easy to replicate and understand, we used a methodical approach to our search and selection process. Following the implementation of the predetermined search strings and screening criteria, records were systematically screened by identifying them, removing duplicates, screening the title and abstract, and last, assessing full-text eligibility. The PRISMA flow diagram shows the record counts at each step and the rationale behind any exclusions. This review adheres to the PRISMA standards for publishing systematic reviews and meta-analyses, which promote openness in the selection of studies. (Moher et al., 2009) . The PRISMA flow diagram (Figure 1) illustrates the process of identifying, screening, and measuring study eligibility, which is then included in the synthesis.

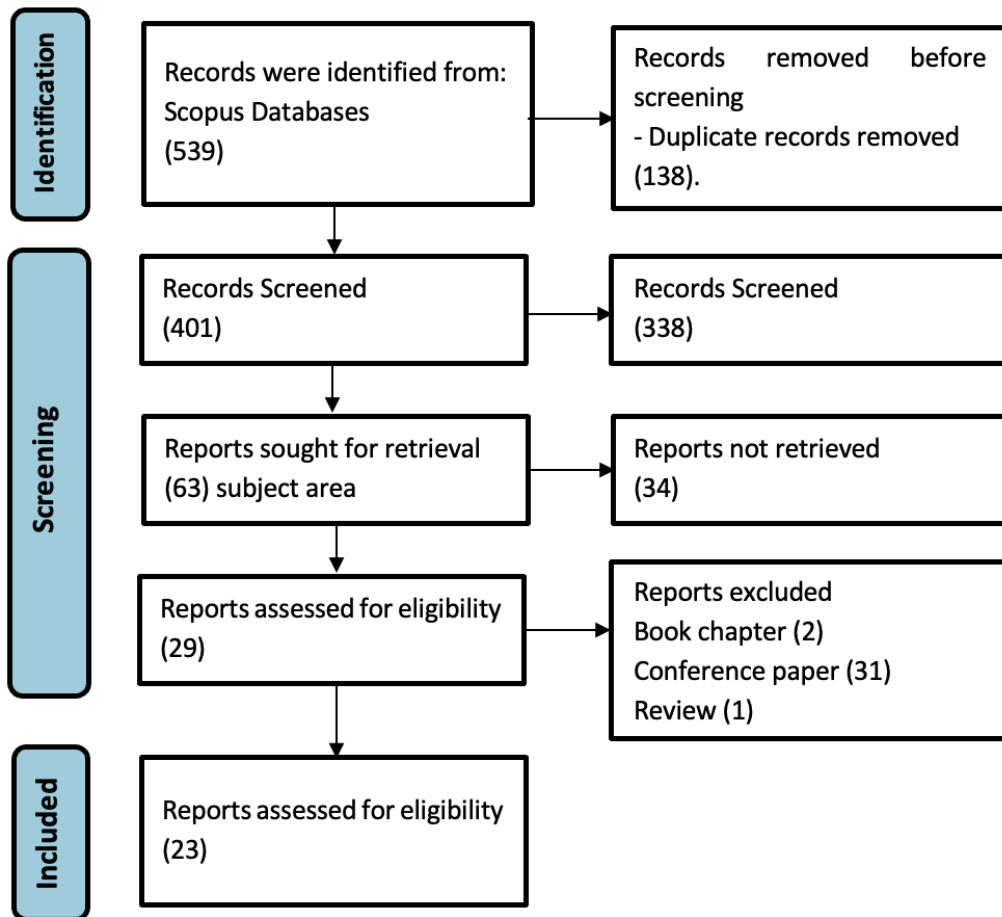


Figure 1. PRISMA flowchart

Scopus yielded 539 results in the first database search. A total of 401 records were subjected to title and abstract level screening after 138 duplicates were removed. Presently, 338 records have been omitted from consideration due to their lack of relevance to ECE or their concentration on the subject of ICT. Then, after screening for fields of study, 34 records were removed from the remaining 63 records that were subject to full-text evaluation. A total of 29 full-text publications were subsequently evaluated for eligibility. For various reasons, 31 conference papers, 2 book chapters, and 1 review were eliminated from the 29 articles that were included. The final synthesis includes 23 papers that fulfilled all inclusion criteria (Figure 1).

*Inclusion and Exclusion Criteria*

To ensure transparency and reproducibility, clear inclusion and exclusion criteria were established prior to the screening process (Table 2). As Roberts & Petticrew (2006) emphasize, the use of explicit criteria is fundamental in systematic reviews to reduce bias and define the scope of evidence considered. In this review, the criteria were designed to focus specifically on ICT in early childhood education (Table 2).

**Table 2. Inclusion and Exclusion Criteria**

Database	Inclusion	Exclusion
Publication type	Peer-reviewed journal articles	Conference proceedings, book chapters, reviews
Time period	Published between 2016 and 2025	Published outside the specified period
Topic relevance	Articles that explicitly discuss information and communication technology, early childhood education	Studies that only briefly touch on ICT issues, without making them the main focus
Types of studies	Empirical studies (qualitative, quantitative, mixed methods) and conceptual studies directly related to the research question	Editorials, opinion pieces, book reviews, reports, or works that do not have an empirical basis.
Methodological details	Studies that provide adequate methodological descriptions for evaluation	Studies that lack clarity or methodological detail
Language	Written in English	Written in a language other than English

### Data Analysis

This analysis combines thematic synthesis and bibliometric mapping to ensure depth and breadth of interpretation of the selected field of study. According to Thomas & Harden (2008), thematic synthesis is an appropriate method for identifying recurring patterns in qualitative literature through coding, categorization, and theme development. This approach allows the transformation of qualitative findings into descriptive statements that can be integrated into broader thematic categories (Barnett-Page & Thomas, 2009). Thematic synthesis offers flexibility to capture context, experience, and pedagogical dimensions, making it particularly suitable for synthesizing diverse evidence based on information and communication technology in early childhood education.

In this study, the approach applied was systematic article coding, building descriptive categories, and producing a thematic analysis that directly addressed the three research questions that guided the review. To facilitate consistency, a data extraction matrix was created to capture key information, including the author, year of publication, research title, country, research model, participant characteristics, and challenges reported. This procedure reflects the principles of analysis that combine qualitative elements, used to organize extensive evidence into balanced categories (Elo & Kyngäs, 2008).

Thematic synthesis and bibliometric mapping were used to identify broader patterns in this field. Trends in publication output, keyword co-occurrence, and geographical distribution were analyzed to provide insights into the integration of information and communication technology (ICT) in early childhood education. As emphasized by Snyder (2019), combining bibliometric indicators with qualitative synthesis enhances the completeness of the literature, especially in interdisciplinary domains. The integration of these approaches allows this review to achieve optimal depth and breadth. By organizing data based on three research questions—trends, challenges, and recommendations—this study not only reviews available knowledge but also highlights conceptual gaps and future directions for research, practice, and regulatory development.

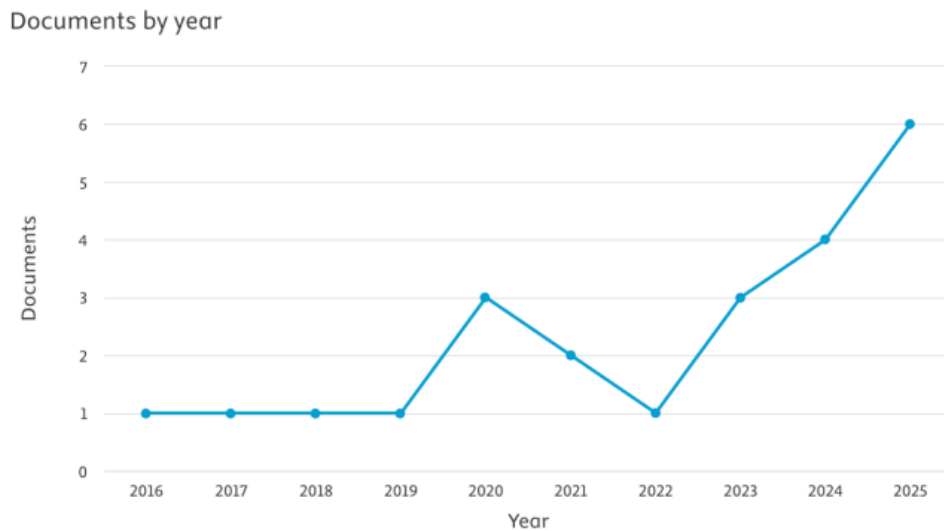
### 3. RESULT AND DISCUSSION

*RQ1. What are the prevailing research trends in ICT in early childhood education over the past decade?*

Increased research in the field of ICT in early childhood education. From 2016 to 2019, one article was published, which became the basis for scientific activities in this field. Then, in 2020, research activity showed an increase with three publications. However, in the following year, the number of publications decreased to two publications in 2021 and one publication in 2022, and then

increased again to three publications in 2023. After that, in the following year, the number of publications continued to increase significantly, with four publications in 2024 and six publications in 2025, which was the most significant growth as it showed the highest output at that time. Figure 2 explicitly illustrates the acceleration of this publication trend post-2020, contributing to the main finding of RQ1 by demonstrating the immediate academic response to the COVID-19 pandemic and the global agenda of educational digitalization. Its specific contribution is demonstrating that the surge from 2023–2025 reflects the urgency of integrating ICT to develop early childhood digital literacy, thus strengthening the argument that this research is not just a trend but a strategic necessity for 21st-century education (Aktas, 2022).

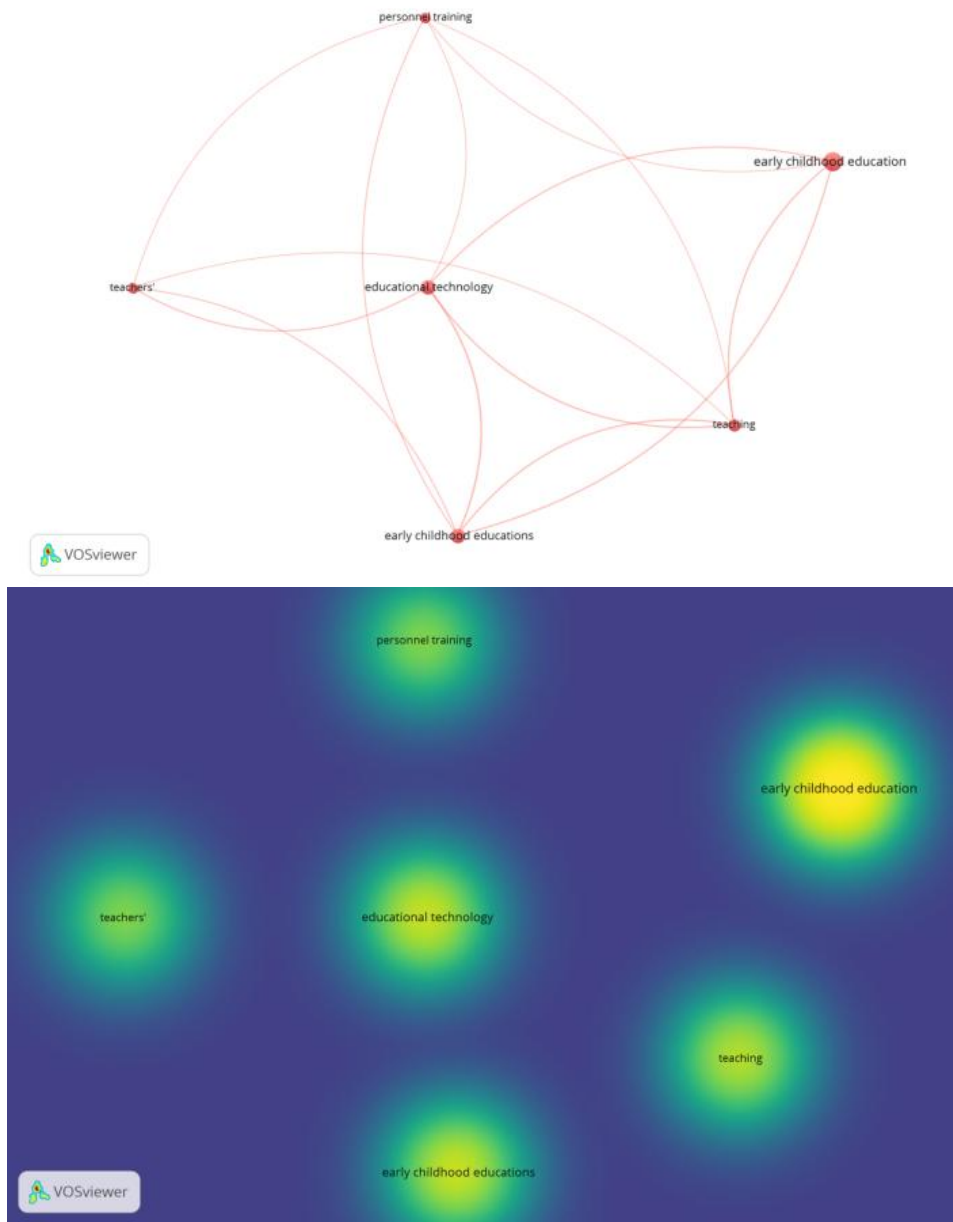
This trend is in line with the increasing global focus on technology in education, particularly in the context of the current era of globalization, which emphasizes education to develop children's digital literacy, creativity, collaboration, and critical thinking skills from an early age through the planned and targeted use of digital media and devices. A number of international studies and policy reports also show that the integration of ICT in ECE is seen as a strategy to enrich learning experiences, facilitate child-centered learning, and prepare children for the knowledge-based demands of the 21st century. Thus, the increase in the number of publications during this period not only reflects growing academic interest, but also scientists' response to the global agenda that encourages the transformation of early childhood education through technological innovation (Ruijia et al, 2025).



**Figure 2. Annual publication trends on ICT in Early Childhood Education (2016-2025)**

Keyword co-occurrence analysis provides in-depth knowledge about the intellectual structure of this sector. The central term "Educational Technology" is related to "Early Childhood Education," "Teachers," "Teaching," and "Personnel Training." In addition, the results of the VOSviewer analysis show that all keywords that appear are in one interconnected thematic cluster, indicating that the research in the dataset has an integrated conceptual focus without fragmentation into different sub-themes (Figure 3). This single cluster shows that terms such as *educational technology*, *teachers*, *teaching*, *personnel training*, and *early childhood education* form a cohesive research network, illustrating the consolidation of knowledge structures in this field. Figure 3(a–b) explicitly contributes to RQ1 by visualizing this single thematic cohesion, indicating a highly consolidated field of study without fragmentation, in line with the bibliometric finding that ICT-ECE research focuses on teacher pedagogy. Its key contribution is confirming that ICT-ECE research is integrated into teacher pedagogy, thus supporting the recommendation of personnel training as a future research priority (Ghozali, 2025). This finding is in line with Van-eck & Waltman's (2014) explanation that the emergence of a single cluster in a co-occurrence map indicates a high level of thematic cohesion, and supports this. According to Callon *et al* (1991) that a network of keywords that is not divided into

several communities indicates a field of study that is still concentrated on core themes and has not undergone significant diversification.



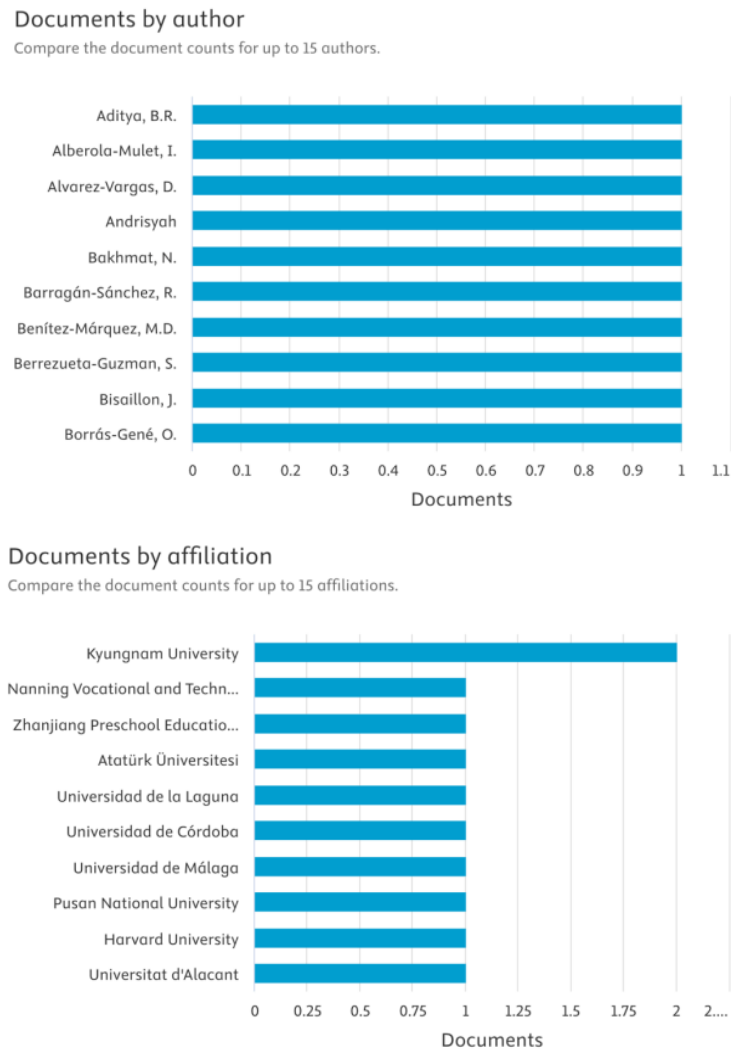
**Figure 3. a) Keyword co-occurrence clusters in ICT research in Early Childhood Education, b) Visualization map of density**

Research productivity in this field of study is driven by small academic communities and institutions, indicating that the basis of ICT in early childhood education remains focused. All researchers or authors, from Aditya, B.R., Alberola-Mulet, I., Alvarez-Vargas, D., Andrisyah, to Borrás-Gené, O, each have one publication to their name. This pattern shows that no author is significantly more productive than others in the dataset. Instead, scientific contributions are evenly distributed among the authors, indicating that developments in this topic are built by a diverse group of individuals without dependence on one or two main contributors. This also indicates that scientific discourse in this field is collaborative and inclusive, with many authors making equal contributions.

In terms of institutional affiliation, based on the results of the "Documents by Affiliation" analysis, Kyungnam University emerged as the institution with the largest contribution, with two publications, placing it at the top in scientific production on this topic. Meanwhile, a number of other institutions showed equal contributions with one publication each, such as Nanning Vocational and

Technical College, Zhanjiang Preschool Education College, Atatürk Üniversitesi, and several universities in Europe, including Universidad de la Laguna, Universidad de Córdoba, Universidad de Málaga, and Universitat d'Alacant. Additional contributions also came from internationally renowned institutions, such as Pusan National University and Harvard University. This pattern shows that even though there is one more productive institution, the development of scientific discourse remains collaborative and involves various higher education institutions from different countries.

Figure 4 (a-b) explicitly illustrates this productivity distribution, contributing to RQ1 by demonstrating an inclusive collaboration model (without elite dominance), where Kyungnam University leads but evenly distributed contributions from Asia-Europe-US support a diverse global discourse. Its specific contribution is highlighting that research growth relies on small but inclusive networks, thus recommending larger-scale cross-institutional collaboration (Nettey, 2024).

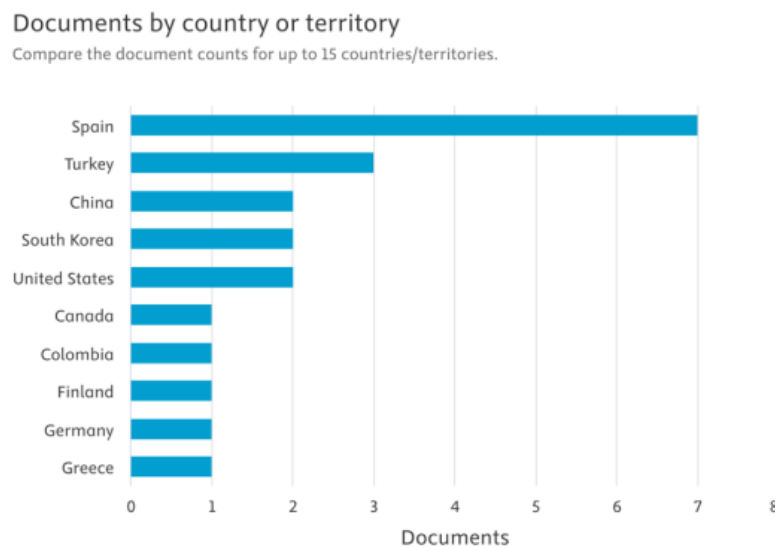


**Figure 4. a) Most productive authors in ICT research in early childhood education (2016–2025) b) Most productive institutional affiliations in ICT research in early childhood education (2016–2025)**

Geographically, the geographical distribution of publications on the challenges faced by teachers in integrating ICT in ECE shows an uneven pattern. Spain emerged as the largest contributor (7 documents), followed by Turkey (3 documents), while countries such as China, South Korea, and the United States each contributed only two publications. The minimal contributions from Canada, Colombia, Finland, Germany, and Greece (one document each) confirm that knowledge production on this topic is still concentrated in certain countries and does not yet reflect a balanced global representation (Figure 5). This uneven geographical pattern also introduces an epistemic bias that privileges experiences and policy models from the Global North while structurally marginalising the realities of teachers in the Global South. As a result, policy recommendations derived from this

literature tend to assume stable electricity, reliable connectivity, and sustained funding, which are often absent in many low- and middle-income contexts, thereby limiting the generalisability and practical relevance of such recommendations for under-resourced settings (Kaur, 2023). A more inclusive evidence base that explicitly incorporates research from African, Asian, and Latin American early childhood settings is therefore needed so that ICT integration guidelines, teacher professional development frameworks, and investment priorities are grounded in a wider range of socio-economic and cultural conditions rather than reproducing a one-size-fits-all, Global-North template (Aktas, 2022).

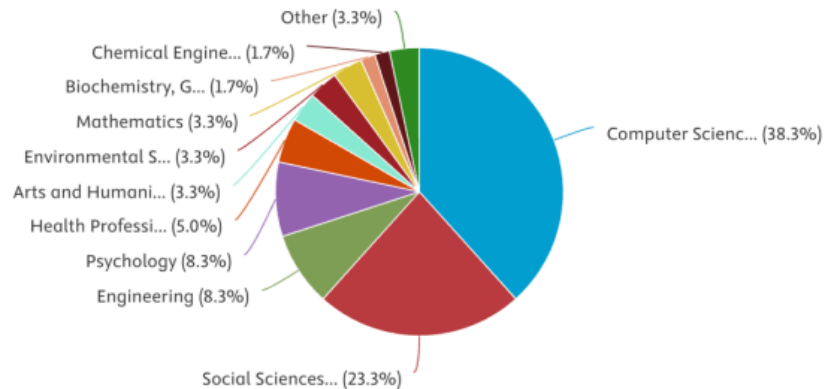
This pattern is in line with literature findings that research on ICT integration in early childhood education is still dominated by countries with more established digital infrastructure and research capacity (Nikolopoulou & Gialamas, 2015). This geographical imbalance has an impact on epistemic bias, as the challenges faced by teachers in the Global South, such as limited devices, unequal internet access, and lack of professional training, tend to be underrepresented in international publications (Dong *et al.*, 2020). Therefore, expanding the contribution of developing countries is important so that the research landscape on ICT integration in ECE can describe more diverse socio-economic and cultural conditions.



**Figure 5. Geographic distribution of ICT publications in early childhood education**

The analysis of field studies reflects the interdisciplinary orientation of this research. Approximately 38.3% of publications were defined in computer science, followed by 23.3% in social sciences, and 8.3% in psychology and engineering, showing that ICT integration in early childhood classrooms depends not only on technical infrastructure but also on teachers' psychological readiness and children's developmental characteristics. In addition, the involvement of *Health Professions* (5%), *Arts and Humanities* (3.3%), and other smaller fields in Figure 5 shows that the adoption of ICT in early childhood education is also influenced by issues of digital health, cultural literacy, and ethical factors in the use of technology. Overall, this distribution of knowledge confirms that the challenges faced by teachers in ICT integration are a cross-disciplinary phenomenon influenced by the interaction between technology, pedagogy, and aspects of child development (Hilmiah & Salehudin, 2024).

## Documents by subject area



Critical reflection on these findings shows that although the number of publications continues to increase and reflects growing scientific interest in ICT integration in ECE, the distribution pattern of research remains uneven. Many studies originate from countries with strong infrastructure such as the United States, the United Kingdom, and Australia, so that the experiences of teachers and policies from the Global South are often not adequately covered (et al., 2022). This imbalance raises an important question: do the available global trends truly represent the dynamics of education in various socio-cultural contexts? In other words, the growth of the literature does indicate positive academic attention, but its geographical distribution reminds us that more inclusive research is still very much needed (Undheim, 2022).

In Along with shifts in distribution, academic approaches to studying ICT integration have also evolved within the last decade. Many publications started to try to analyze the deeper pedagogical influence of gadgets after 2015, particularly as the COVID-19 epidemic pushed the usage of technology in classrooms. It is challenging to evaluate the long-term effects and applicability of digital treatments for various kinds of schools since the majority of research are still descriptive and conducted on a limited scale. (et al., 2023). This is also evident in the lack of longitudinal or cross-national comparative research, which could provide a more complete picture of how policy, culture, and access to technology shape practices in the field (Liu et al., 2024). Thus, although the variety of topics is increasingly rich, ranging from digital literacy to simple robotics, there is still limited evidence to conclude long-term effectiveness.

Another interesting trend is the growing pedagogical focus. Researchers are not only highlighting technology as a learning aid, but are also beginning to explore how teachers and children can build meaningful digital experiences through play, storytelling, or creative collaboration (Undheim, 2022). This shift is in line with the push by international institutions such as UNESCO to place 21st-century skills as an important part of early childhood education (UNESCO, 2020). However, for this research direction to have a real impact, the field needs to expand the scope of research to more areas, use stronger research designs, and ensure that findings can be applied in a relevant manner in diverse contexts. In other words, the future of ICT integration research in ECE requires a more inclusive, collaborative, and sensitive approach to the realities of education in different parts of the world.

**RQ2. What are the challenges and obstacles teachers face in integrating ICT in early childhood education?**

The integration of ICT in early childhood education is increasingly seen as an important element in supporting learning processes that are relevant to the current era. However, a review of the literature shows that teachers face a variety of challenges that significantly limit the effectiveness of its application in early childhood education classrooms. These obstacles include limitations in infrastructure and access to devices, a lack of adequate professional training, teachers' doubts about children's readiness, and socio-cultural gaps that affect the acceptance and use of technology in the local context. In addition to technical factors, many teachers also find it difficult to balance the use of

ICT with play-based pedagogical principles, so that the integration process often does not run optimally.

To provide a more comprehensive picture of these challenges, Table 3 summarizes findings from 23 empirical and conceptual studies published between 2016 and 2025. This synthesis highlights the most frequently reported patterns of obstacles, ranging from issues of teacher competence to policy and curriculum pressures that are not always in line with early childhood learning practices. Through this mapping, it can be seen that the challenges of ICT integration are not only related to the availability of technology, but also reflect the pedagogical, structural, and cultural dynamics that influence teacher practices in various global contexts.

**Table 3. Challenges and Barriers in ICT Integration in Early Childhood Education**

No	Author & Year	Article Title	Teacher Challenges
	Bakhmat <i>et al.</i> (2025)	Mobile Gaming Technology and Cognitive Development in Ukrainian Preschool and Primary Education: A Correlational Study	This article focuses on the positive relationship between the use of <i>mobile game</i> technology and cognitive development, so the challenges faced by teachers are not explicitly mentioned.
2	Fernández-Montoro <i>et al.</i> (2025)	Modeling Training Using Information and Communication Technology in Early Childhood Education with Functional Diversity: A Case Study in Spain	The need for early assessment (initial evaluation) and increased material and human resources in public institutions. Urgent administrative restructuring is needed to accelerate the distribution of financial aid and more specialized professional funding.
3	Dogan & Gogus (2025)	The Influence of Learning Technology Courses on Prospective Teachers' Competence in Utilizing Web 2.0: A Case Study of Early Childhood Education Programs	The two-hour duration of the 'Instructional Technologies' course limits the long-term retention of Web 2.0 skills. Improvements are needed in the proficiency of digital teaching visual material design.
4	Li <i>et al.</i> (2025)	Research on Improving the Educational Research Capabilities of Early Childhood Education Teachers Supported by Big Data Technology	This article aims to address existing issues in the research capabilities of early childhood education teachers using Big Data, but the specific details of the challenges are not explained in the abstract.
5	Berrezueta-Guzman & Dolón-Poza (2025)	Enhancing Preschool Children's Language Acquisition Through Robot Assistants: An Evaluation of Effectiveness, Engagement, and Acceptance	Challenges such as student <i>distractions</i> and the need for consistent teacher <i>supervision</i> .
6	Clements & Sarama (2025)	The Best of Both Worlds: Developing an Innovative, Integrated, Intelligent, and Interactive Technology System to Support Face-to-Face and Digital Experiences for Early Childhood Mathematics	Most early childhood children and teachers cannot access research-based early childhood mathematics resources ( <i>research-based early childhood mathematics resources</i> )

No	Author & Year	Article Title	Teacher Challenges
7	Hijón-Neira <i>et al.</i> (2024)	AI-Generated Context for Teaching Robotics to Improve Computational Thinking in Early Childhood Education	The importance of providing the right context and support to encourage prospective teachers to build confidence and embrace educational technology.
8	Boude <i>et al.</i> (2024)	Key Features of Mobile Applications to Assist Early Childhood Educators	Teachers often use academic applications (from app stores) that are not designed by early childhood educators, which fail to improve the training process in early childhood education.
9	Markos <i>et al.</i> (2024)	Prospective Teachers' Assessment of ChatGPT's Usefulness in Higher Education: SWOT Analysis and Content	Addressing challenges that arise in educational technology, such as the integration of artificial intelligence in the teaching and learning process. However, the details of the challenges (Weaknesses/Threats) cannot be explained in the abstract.
10	Yang <i>et al.</i> (2024)	Are you ready to face a high-tech future? Preservice preschool teachers' pedagogical content knowledge of technology in China and the factors that predict it	The majority of pre-service teachers (81%) demonstrated low to moderate levels of Technological Pedagogical Content Knowledge (TPACK).
11	Gözüm <i>et al.</i> (2023)	Development of a Teacher Self-Efficacy Scale in the Use of ICT at Home for Preschool Distance Education During Covid-19	The focus on developing a teacher <i>self-efficacy</i> scale for ICT use implies that teacher <i>self-efficacy</i> in ICT is an area of concern/challenge that needs to be measured.
12	Kim & Jeong (2023)	The Application of Programming in Early Childhood Education: A Modified Technology Acceptance Model Approach	Exploring teachers' acceptance and readiness for educational <i>coding</i> , showing that factors such as <i>self-efficacy</i> , perceived ease of use, and teacher/parent readiness are important factors that can be challenging if low.
13	Muvid (2023)	Integrative Learning Models in Early Childhood Education in the Digital Age	Teachers need good self-regulation strategies to achieve ambitious learning goals. Lack of <i>IT experience</i> and <i>IT motivation</i> can affect teachers' self-regulation strategies for digital learning.
14	Stockless <i>et al.</i> (2022)	Prospective Teachers' Competencies and Pedagogical Use of ICT: Are They Ready to Develop Collaborative Activities with Students?	Uncertainty about pre-service teachers' (PSTs) ability to transfer ICT competencies to real-world contexts. Mastery of digital tools does not exceed the "good" level (except for office software). Self-perceived mastery of is average in terms of ICT integration skills.
15	Alberola-Mulet <i>et al.</i> (2021)	Teachers' beliefs about the role of digital educational resources in educational practice: a qualitative study	Issues or limitations related to digital student training <sup>49</sup> . There is no context regarding the appropriate level of integration of digital resources.
16	Kao <i>et al.</i> (2020)	Teachers' Beliefs and Strategies for Online Academic Learning in Early Childhood Education in Taiwan	Pre-service teachers did not demonstrate the use of their ICT literacy in bold academic learning strategies <sup>53</sup> . Excessive courageous experiences among pre-

No	Author & Year	Article Title	Teacher Challenges
			service teachers can result in less positive beliefs.
17	Romero-Tena <i>et al.</i> (2020)	Challenges in initial training for early childhood education teachers. A cross-sectional study of their digital competencies	The challenge in early childhood education teacher training is the need to manage a training plan that enables future teachers to position themselves at an expert level of digital competence.
18	Garcia (2020)	Kinder Learns: Educational Visual Novel Games as a Tool for Knowledge Improvement in Early Childhood Education	This article focuses on the acceptance and positive influence of digital games, so the challenges faced by teachers are not explicitly mentioned.
19	Pérez-Jorge <i>et al.</i> (2020)	Digital Skills Training for Early Childhood: The Case of La Laguna University Teachers	The need for digital skills training implies challenges in mastering digital competencies.
20	Marin-Diaz <i>et al.</i> (2019)	Determining problematic social media use by students	Issues related to the context and/or ICT technology context, particularly social networking, by students (including pre-service teachers).
21	Lee & Kim (2017)	Concept Map Analysis of ICT Education for Early Childhood Education Teachers	The need for teacher training to develop more diverse, comprehensive, and specific ICT concepts.
22	Mertala (2017)	Wagging the Dog - The Nature and Foundations of Positive ICT Pedagogical Beliefs Among Preschool Educators	Implied challenge: <i>top-down</i> policies/approaches may not be effective in fostering positive ICT pedagogical beliefs, which instead grow from processes driven by teachers themselves.
23	Topraklikoglu & Öztürk (2021)	Research on the influence of augmented reality applications in education on the behavior patterns of children in early childhood education.	It is necessary to provide collaborative and interactive learning with augmented reality toys <sup>75</sup> , because children do not show high cognitive achievement through interaction with these toys.

The synthesis of evidence presented in Table 3 shows that the challenges teachers face in integrating ICT in early childhood education in the field are far more complex than is often assumed. Many studies show that teachers face very fundamental structural constraints, such as a lack of infrastructure, access to devices, and supporting resources in public institutions (Fernández-Montoro *et al.*, 2025). Even when technology is available, teachers still face limitations in technical and pedagogical capabilities—for example, the low level of TPACK among preschool teacher candidates in China (Yang *et al.*, 2024), or the inability of PSTs to transfer digital competencies to actual teaching practice (Stockless *et al.*, 2022). Several studies also highlight that ICT training provided to teachers is often too short, lacks practical application, or does not emphasize digital material design skills (Dogan & Gogus, 2025), thus failing to build a truly lasting foundation of skills. Thus, the challenge for teachers is not simply a matter of "lack of training," but rather a mismatch between technological demands and available structural and pedagogical capacities.

On the other hand, the psychological aspects and beliefs of teachers also play an important role in the success of ICT integration. Research shows that teachers' self-efficacy regarding ICT remains a fragile area that needs to be measured seriously (Gözüm *et al.*, 2023), while acceptance of new technologies such as programming or educational robots is greatly influenced by factors such as perceived ease, ICT experience, and internal motivation (Kim & Jeong, 2023; Muvid, 2023). Interestingly, several studies reveal that teachers' pedagogical beliefs about ICT are not always shaped by top-down policies, but rather grow through reflective processes and direct experience (Mertala, 2017). This shows that increasing the use of ICT requires more than just providing technology or training modules; it requires a more in-depth approach to strengthen teachers' self-regulation, self-confidence, and sustainable pedagogical beliefs. Without this psychological

foundation, ICT implementation will easily become superficial and not integrated with play-based learning practices, which are the main characteristics of ECE.

An further issue that often gets disregarded is the disparity between the caliber of technology and its use in schools for young children. Research shows that most of the digital tools used in the classroom were not created by professionals in the field of early childhood education, meaning they do not cater to the specific requirements of students in this age group. (Boude *et al.*, 2024) . There is also the problem of student distraction when using educational robots, which requires much more intense supervision by teachers (Berrezueta-Guzman & Dolón-Poza, 2025) . In addition, research on interactive mathematics learning systems shows that both teachers and children often do not have access to quality research-based technology (Clements & Sarama, 2025) . Even when the technology "works," many pre-service teachers do not utilize their ICT literacy in online learning strategies (*et al.*, 2020) . Taken together, these findings highlight that the challenges of ICT integration are not merely technical issues but also involve pedagogical suitability, contextual readiness, and teachers' ability to manage digital interactions sensitively according to the developmental characteristics of young children. In other words, its success depends on the quality of the ecosystem, not just the availability of devices.

#### 4. CONCLUSION

According to this research, the disparity between pedagogical needs, professional preparedness, and institutional capacity is the primary cause of the difficulties educators have when trying to incorporate ICT into ECE, even more so than a shortage of equipment. The deployment of ICT is sometimes superficial and does not completely support play-based learning due to technical constraints, immature digital capabilities, and the variability in the quality of digital learning materials. There is a lack of representation of developing country context in the global picture due to geographical bias in the literature, which is also shown by the study. Consequently, strategic measures include investing in early childhood-specific resources, conducting cross-regional research, empowering educators via ongoing professional development, and enacting regulations that are more flexible and responsive to changing needs. To build integration models that are sensitive to local cultural and pedagogical demands, further research is required to establish longitudinal and comparative methodologies for understanding the long-term effects of ICT usage. However, it is important to note that this evaluation does have certain limitations. The first limitation is that the literature review could not have used any other databases than Scopus, which may have missed pertinent research that were indexed in other repositories. Second, the inclusion of just articles in English may have led to an underrepresentation of research published in local languages, especially in the Global South. To overcome these limitations and present a more inclusive and thorough picture of ICT integration in early childhood education, future evaluations should combine numerous databases and multilingual sources. This will help ensure that the results are full and applicable.

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