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TPACK in Early Childhood Education: A Bibliometric Analysis of Global Research (2017–2025)

✉[1]**Maisarah,** [2]**Cyndi Prasetya,** [3]**Nova Yurika**
[1,2] Universitas Samudra, Langsa, Aceh, Indonesia
[3] Ghent University, Sint-Pietersnieuwstraat 33, 9000 Gent, Belgium
[1] maisarah@unsam.ac.id, [2] prasetya.cyndi@unsam.ac.id, [3] nova.yurika@imbrsea.eu
orcid ID: https://orcid.org/0000-0001-8608-6930

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Abstrak

Penelitian tentang Technological Pedagogical Content Knowledge (TPACK) dalam pendidikan anak usia dini (PAUD) terus berkembang seiring meningkatnya integrasi teknologi dalam pembelajaran. Namun, pemetaan tren, fokus, dan perkembangan riset TPACK dalam PAUD masih terbatas. Penelitian ini bertujuan untuk menganalisis secara bibliometrik perkembangan publikasi ilmiah terkait TPACK dalam pendidikan anak usia dini. Jenis penelitian ini adalah penelitian kuantitatif dengan pendekatan bibliometrik. Populasi penelitian berupa seluruh artikel ilmiah bertema TPACK dan PAUD yang terindeks pada basis data Scopus dan Google Scholar, dengan sampel sebanyak 312 artikel yang dipublikasikan pada periode 2017–2025. Instrumen penelitian berupa lembar dokumentasi dan perangkat lunak VOSviewer. Analisis data dilakukan menggunakan analisis deskriptif bibliometrik dan pemetaan visual jejaring kata kunci, penulis, dan sitasi. Hasil penelitian menunjukkan peningkatan signifikan publikasi TPACK PAUD, dengan fokus dominan pada kompetensi guru, integrasi teknologi digital, dan pembelajaran berbasis permainan.
Kata kunci: TPACK; pendidikan anak usia dini; bibliometrik; integrasi teknologi; kompetensi guru.

Abstract

Research on Technological Pedagogical Content Knowledge (TPACK) in early childhood education has grown rapidly along with the increasing integration of technology in learning. However, comprehensive mapping of research trends and themes remains limited. This study aims to conduct a bibliometric analysis of scholarly publications on TPACK in early childhood education. This quantitative study employed a bibliometric approach. The population consisted of all TPACK-related early childhood education articles indexed in Scopus and Google Scholar, with a sample of 312 articles published between 2017 and 2025. Data were collected using documentation sheets and analyzed with VOSviewer software. Bibliometric descriptive analysis and visualization of keyword, author, and citation networks were applied. The findings reveal a significant increase in TPACK-related publications, with dominant themes focusing on teacher competence, digital technology integration, and play-based learning in early childhood settings.
***Keywords**: TPACK; early childhood education; bibliometric analysis; technology integration; teacher competence.*

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A. INTRODUCTION

The development of digital technology has brought significant changes to learning practices at various levels of education, including early childhood education (PAUD). The integration of technology into PAUD is no longer inevitable, given the demands of 21st-century learning and the increasing use of digital media in children's lives. However, the application of technology in PAUD requires a careful approach, as it must be tailored to the characteristics of child development and the principles of early childhood education. Therefore, early childhood education teachers are not only required to master pedagogical materials and strategies, but also to have the ability to integrate technology appropriately and meaningfully.

In that context, the framework Technological Pedagogical Content Knowledge (TPACK) is an important conceptual approach for understanding teacher competency in integrating technology into learning. TPACK emphasizes the integration of content knowledge, pedagogy, and technology as an interconnected and inseparable whole (Mishra & Koehler, 2006; Mishra & Koehler, 2017). This framework provides a theoretical foundation that technology is not merely a learning tool, but an integral part of pedagogical design aimed at improving the quality of learning processes and outcomes.

The urgency of TPACK mastery for early childhood education teachers is growing as the digital transformation of education accelerates, particularly in the wake of the COVID-19 pandemic. Various studies have shown that limited TPACK competency among early childhood education teachers results in the use of technology, which tends to be technical in nature and does not fully support children's cognitive, social, and emotional development (Nasution, 2022; Hidayati & Fitria, 2023). International reports also confirm that without adequate pedagogical preparedness, technology integration in early childhood education has the potential to reduce the quality of children's learning interactions and play experiences (UNESCO, 2019; OECD, 2020). This demonstrates that TPACK mastery is a crucial prerequisite for ensuring quality early childhood education in the digital era.

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Although research on TPACK has grown rapidly over the past two decades, previous research indicates that the primary focus of TPACK studies is still dominated by the context of primary and secondary education, and teacher education in general. Studies specifically addressing TPACK in the context of early childhood education are relatively limited and scattered, both in terms of focus and research areas (Voogt et al., 2018; Chai et al., 2019). Furthermore, most research on TPACK in Early Childhood Education (PAUD) is local empirical, such as survey studies or teacher training, without systematic mapping of developments, thematic trends, and patterns of research collaboration globally.

Based on these conditions, a comprehensive study is needed that can map the development of TPACK research in early childhood education systematically and based on data. This study is novel in that it is the first to systematically synthesize and visualize global TPACK research in early childhood education through a large-scale bibliometric analysis, thereby revealing longitudinal trends and collaborative structures that have not been explicitly addressed in prior empirical or review studies. The novelty of this study lies in the use of a bibliometric approach to analyze publication trends, thematic focus, country contributions, and collaborative networks of TPACK PAUD research based on articles indexed in the Scopus and Google Scholar databases for the period 2017–2025. Unlike previous studies that focused on the implementation or measurement of TPACK PAUD teachers, this study provides a macro overview of the TPACK research landscape in PAUD globally and longitudinally.

Thus, this research is expected to provide theoretical contributions in enriching TPACK studies in the context of early childhood education, as well as practical contributions as a basis for policy development, PAUD teacher training programs, and future research directions. Based on the description, the problem formulation in this study is how the publication trends, study focus, and collaboration patterns of TPACK research in early childhood education based on bibliometric analysis.

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B. RESEARCH METHODS

This research uses an approach quantitative and qualitative descriptive interpretation using bibliometric methods. A quantitative approach was used to analyze numerical publication patterns, such as the number of articles, annual trends, author productivity, country contributions, and keyword frequency. Meanwhile, a descriptive qualitative approach was used to interpret the meaning, thematic focus, and research trends based on the results of contextual bibliometric mapping.

A descriptive qualitative approach is understood as a research process aimed at understanding and interpreting phenomena based on non-numerical data in a systematic and contextual manner (Creswell, 2018). In bibliometric research, qualitative analysis plays a crucial role in explaining relationships between concepts, the meaning of keyword clusters, and the theoretical implications of citation patterns and scientific collaborations that cannot be understood through quantitative data alone (Zupic & Čater, 2015; Donthu et al., 2021). Thus, the combination of quantitative and qualitative approaches allows for a more comprehensive mapping of TPACK research in early childhood education.

The population of this study includes all scientific articles that discuss Technological Pedagogical Content Knowledge (TPACK) in the context of early childhood education indexed in the database Scopus as the main database and Google Scholar as a supporting database. Scopus was selected based on its reputation and consistency in indexing internationally reputable journals, while Google Scholar was used to expand the scope of publications, particularly relevant national journal articles. The research sample was determined using the technique purposive sampling with the following criteria: (1) scientific journal articles; (2) published in the period 2017–2025; (3) relevant to the topic of TPACK and early childhood education; and (4) available in full text. Based on these criteria, 312 articles were obtained as study objects.

Given the use of two databases, there is a potential risk of data duplication, particularly for articles indexed simultaneously in Scopus and Google Scholar. To minimize this risk, a data cleaning process was conducted prior to analysis by cross-checking article titles, authors, publication years, journal names, and Digital Object Identifiers (DOIs). Duplicate records identified across databases were removed, and only

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one representative entry was retained for analysis. This procedure ensured data consistency and prevented the overestimation of publication counts, author productivity, and citation metrics.

Data collection was conducted through documentation techniques using the keywords "TPACK," "early childhood education," "early childhood," and related equivalents. The research instrument was a documentation sheet systematically arranged to record bibliographic information on articles and software. VOSviewer was used to map bibliometric networks. The instrument grid is presented in Table 1:

Table 1. TPACK Bibliometric Research Instrument Grid in PAUD

No	Aspects Analyzed	Indicator	Data Source
1	Publication Identity	Article title, year of publication, journal name	Article metadata (Scopus & Google Scholar)
2	Publication Productivity	Number of articles per year	Article metadata
3	Author Contribution	Author name, number of publications	Article metadata
4	State Contribution	Authors' institutional and country affiliations	Article metadata
5	Study Focus	Primary keywords and additional keywords	Abstract & keywords of the article
6	Keyword Network	Theme clusters, relationships between keywords	VOSviewer Analysis
7	Citation Pattern	Number of citations and most influential articles	Citation metadata
8	Scientific Collaboration	Relationship between authors and institutions	VOSviewer network analysis

Data analysis was conducted through quantitative descriptive analysis to identify publication trends and article characteristics, as well as descriptive qualitative analysis of the visualization of keyword networks, authors, and citations to reveal the focus and development of TPACK research in PAUD.

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C. FINDINGS AND DISCUSSION

1. Trends in the Development of TPACK Research Publications in Early Childhood Education

Based on a bibliometric analysis of 312 articles indexed in the Scopus and Google Scholar databases, research onTechnological Pedagogical Content Knowledge (TPACK) in early childhood education (PAUD) shows a significant and sustainable increasing trend in the period 2017–2025. The number of publications in the initial period (2017–2018) was still relatively limited and dominated by conceptual studies that attempted to adapt the TPACK framework to the context of early childhood education. Research in this phase generally addressed issues of teacher readiness, the potential use of technology, and the pedagogical limitations of technology use in early childhood (Voogt et al., 2018).

A consistent increase in the number of publications began in 2019. This trend intensified in 2020–2022, which coincided with the COVID-19 pandemic. This situation accelerated the adoption of digital technology in early childhood education and created an urgent need for teachers' TPACK competencies in online and hybrid learning environments. A similar phenomenon was also reported in educational bibliometric studies, which showed a surge in publications related to technology integration post-pandemic (Donthu et al., 2021; Zulkifli & Ahmad, 2023).

Peak publication in 2024, as shown in**Table 1**This indicates that TPACK research in early childhood education (ECE) has evolved from a crisis-responsive issue to a systemic and sustainable research agenda. This finding aligns with Mishra and Koehler's (2017) assertion that TPACK is a long-term framework for teacher professional development, including in the context of early childhood education. Therefore, this publication trend reflects growing academic awareness of the importance of pedagogical and contextual technology integration in ECE.

2. Country Contribution and Research Context Dynamics

The analysis of country contributions shows that TPACK research publications in early childhood education (ECE) are dominated by developing countries, particularly Indonesia, followed by the United States, Australia, and Malaysia. Indonesia's dominance

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in this publication landscape can be traced to increased attention to strengthening early childhood education teacher competencies, educator digital literacy, and national policies related to the digital transformation of education (Maisarah et al., 2025; Hidayati & Fitria, 2023).

Most publications from Indonesia are still dominated by national collaborations, with relatively limited international engagement. In contrast, research from developed countries tends to involve cross-institutional and cross-national collaborations, and focuses on the development of technology-based learning models oriented toward students child-centered learning and evaluation of education policies (OECD, 2020).

These differences demonstrate that the social, cultural, and policy contexts of education significantly influence the direction and focus of TPACK research in early childhood education (ECE). The predominance of developing countries also indicates that technology integration in ECE still faces fundamental challenges, particularly related to teacher readiness and infrastructure. Therefore, these results underscore the importance of TPACK research that is sensitive to local contexts while remaining open to global collaboration.

3. Mapping the Study Focus Based on Keyword Networks

Keyword network mapping using VOSviewer software resulted in three main thematic clusters, as shown in**Figure 1**.

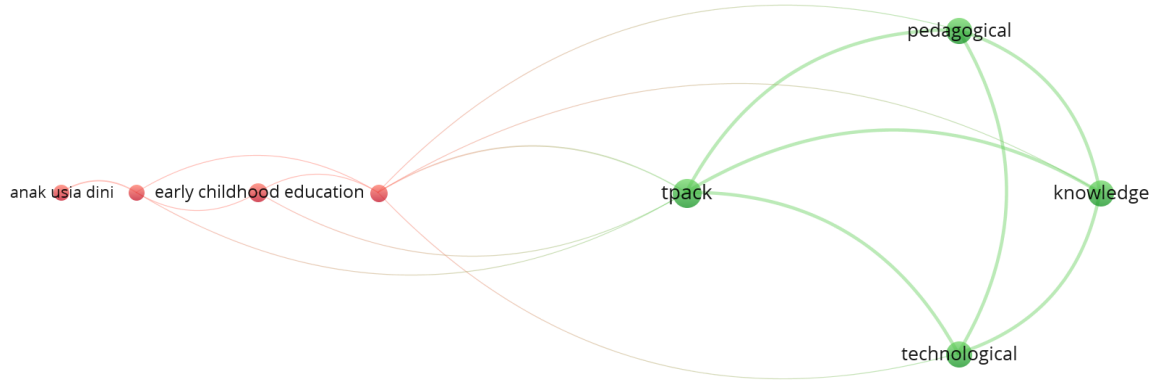

Figure 1. Mapping of Study Focus Based on Keyword Network

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The first cluster is centered on keywords TPACK, teacher competence, And professional developmentThe dominance of this cluster indicates that the primary focus of TPACK research in early childhood education (PAUD) is directed at strengthening the professional competence of teachers as key actors in the integration of learning technology. This finding aligns with research by Angeli and Valanides (2017) and Schmidt et al. (2019), which confirmed that teachers' TPACK mastery significantly contributes to the quality of technology-based learning design and implementation.

The second cluster highlights the themedigital technology, online learning, And educational mediaThis cluster has emerged frequently in post-pandemic publications and reflects increased attention to the use of digital media, online platforms, and learning apps in early childhood education (ECE). However, several studies in this cluster also criticize excessive and undirected technology use, which has the potential to diminish the quality of children's social interactions and play experiences (UNESCO, 2019; OECD, 2020).

The third cluster is related toplay-based learning, early childhood pedagogy, And child developmentThe existence of this cluster confirms that TPACK research in Early Childhood Education (PAUD) cannot be separated from the pedagogical principles unique to early childhood. Technology integration is understood as a means to enrich play-based learning, not as a substitute for play itself (Setiawan, 2021; Zulfitri, 2022). Thus, Figure 1 shows that TPACK in PAUD is developing as an integrative approach that aligns technology, pedagogy, and child developmental characteristics.

4. Citation Patterns and Influential Articles in TPACK PAUD Research

Citation analysis shows that the most frequently cited articles in TPACK PAUD research originate from conceptual works and systematic reviews of TPACK. Articles by Mishra and Koehler (2006; 2017), Voogt et al. (2018), and Chai et al. (2019) serve as the primary references that form the theoretical foundation of TPACK research. The predominance of citations to these works indicates that empirical research on TPACK PAUD remains heavily reliant on the general conceptual framework of TPACK.

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However, the analysis also shows an increase in citations to empirical articles specifically examining the context of early childhood education (ECE), particularly research addressing teacher TPACK training, digital literacy, and game-based technology integration (Maisarah et al., 2025; Nasution, 2022). This indicates that the ECE context is beginning to gain stronger recognition in the global TPACK discourse.

On the other hand, the citation rate of articles from national journals, including the Raudhah Journal, is still relatively low compared to international journals. This finding aligns with bibliometric studies that suggest that visibility and citation impact are significantly influenced by international collaboration and journal indexing (Zupic & Čater, 2015; Donthu et al., 2021). Therefore, improving the quality of methodologies and collaborative networks is a crucial strategy for increasing the impact of TPACK PAUD research from a local context.

5. Implications of Findings for the Development of Early Childhood Education Research and Practice

Overall, these bibliometric results confirm that TPACK is an increasingly relevant framework for addressing the challenges of technology integration in early childhood education. The dominant focus on teacher competency, as reflected in the keyword clusters in Figure 1, indicates that successful technology utilization is largely determined by the pedagogical and professional preparedness of educators. In the context of early childhood education, technology must be positioned as a learning support tool that enriches children's play experiences and social interactions (Mishra & Koehler, 2017; UNESCO, 2019).

These findings also have practical implications for the development of policies and training programs for early childhood education (PAUD) teachers. TPACK training needs to be designed holistically, integrating aspects of technology, pedagogy, and an understanding of child development. Therefore, the results of this study not only provide theoretical contributions but also serve as an empirical basis for continuously strengthening the TPACK competencies of early childhood education (PAUD) teachers.

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D. CONCLUSION AND SUGGESTIONS

The results of the bibliometric analysis show that the research Technological Pedagogical Content Knowledge (TPACK) in early childhood education has seen a significant increase, particularly post-2020, indicating a growing focus on technology integration in early childhood education. However, keyword mapping reveals that studies are still dominated by pedagogical and basic technology aspects, while the integration of TPACK with early childhood developmental characteristics and play approaches remains limited. Furthermore, contributions from international publications and collaborations are uneven, opening up opportunities for developing locally context-based research.

Based on these findings, further research is recommended to develop TPACK studies that are more contextualized to the developmental needs of early childhood, employ diverse empirical designs, and expand cross-national collaboration. Practically, the results of this study can serve as a reference for developing policies and early childhood teacher training programs oriented toward pedagogically and sustainably integrating TPACK. In the Indonesian PAUD policy context, these findings underscore the need to explicitly embed TPACK competencies into national teacher professional development frameworks, curriculum guidelines, and digital literacy policies to ensure developmentally appropriate and equitable technology integration in early childhood education.

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