



The Competency Gap of Early Childhood Education Teachers in Technology-Based Learning : A Digital Literacy Perspective Between Technology Use and Instructional Design

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ABSTRACT

This study aims to analyze the competency gap of early childhood education (ECE) teachers in technology-based learning from a digital literacy perspective, particularly between technology use and instructional design. The study employed a quantitative approach with a cross-sectional survey design involving 217 ECE teachers selected through purposive sampling. Data were collected using a Likert-scale questionnaire (1-5), which was validated using product moment correlation and tested for reliability using Cronbach's Alpha ($\alpha = 0.964$). Data were analyzed using descriptive statistics and gap analysis. The results indicate that teachers' competencies in technology-based learning are at a moderate level (mean = 2.55). The technology use dimension shows a higher mean score (2.60) compared to instructional design (2.46), with a gap of 0.14. These findings suggest that teachers are capable of using technology in learning activities but have not yet optimally developed systematic technology-based instructional design. This gap indicates that teachers' digital literacy remains at the operational level and has not yet progressed to higher levels involving creation and integration. The implications of this study highlight the need to strengthen teacher competencies through professional development programs emphasizing technology-based instructional design, practice-oriented training, and systemic support to enhance digital literacy comprehensively. This study contributes to the advancement of digital literacy and technology integration in early childhood education and provides a foundation for developing future teacher competency improvement models.

Keywords: Digital literacy, Early childhood teachers, Technology-based learning, Instructional design, Teacher competency

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INTRODUCTION

The rapid advancement of digital technology has brought significant changes to the field of education, including early childhood education (ECE). The integration of technology into learning is expected not only to enhance the effectiveness of the learning process but also to support children's cognitive, social, and emotional development optimally. In this context, ECE teachers are required to possess comprehensive digital literacy competencies, which include technical skills, critical thinking, creativity, and the ability to design technology-based learning aligned with children's developmental characteristics (Ghosh & Kumar, 2026; Manditereza et al., 2026; Ncube, 2026; Saulénienè et al., 2025; Sofkova Hashemi & Cederlund, 2017). Therefore, technology should not merely function as a supporting tool but as an integral component of meaningful instructional design.

However, empirical evidence indicates a contrasting reality. While most ECE teachers are able to use digital technology, its application remains limited to basic functions such as documentation or assessment, without being systematically integrated into instructional design. Technology is often used as a substitute rather than as part of a comprehensive pedagogical strategy, resulting in suboptimal learning outcomes (Nurhayati & Judijanto, 2025, 2026; Wang, 2024). This condition suggests that teachers' digital literacy is still at an operational level and has not yet developed toward creative and integrative dimensions, reflecting an imbalance between technical and pedagogical competencies (Hurtado-Mazeyra et al., 2025; Saul nien  et al., 2025; Zheng, 2026).

The gap between technology use and instructional design competence has become a critical issue in technology-based learning in ECE. Teachers who are capable of using technology but lack strong instructional design skills are likely to produce superficial learning experiences that do not align with children's developmental needs. Moreover, limited conceptual understanding of digital literacy leads to misalignment between technology integration and learning objectives, thereby reducing the quality of children's learning experiences (Hasibuan et al., 2024; Nurhayati & Judijanto, 2026;  ahin, 2026). Variations in instructional design are also influenced by teachers' competencies, pedagogical beliefs, and technological pedagogical content knowledge (TPACK), which determine the extent to which technology can be effectively integrated into learning (Chheang et al., 2026; Dewi et al., 2025; Julia et al., 2020; Nugraha et al., 2022, 2023).

This competency gap is influenced by multiple interrelated factors, including the limitations of professional development programs that tend to emphasize technical skills rather than instructional design, inadequate infrastructure, and teachers' attitudes and beliefs toward technology use. Teachers with positive pedagogical beliefs are more likely to integrate technology effectively, whereas limited access and institutional support become significant barriers to implementation (Dogan & Gogus, 2025; Hasibuan et al., 2024;  ahin, 2026). Additionally, socio-cultural contexts influence how technology is integrated into learning, requiring teachers to adapt its use to local values and children's needs (Nurhayati & Judijanto, 2026). The lack of structured and sustainable digital competency development programs further exacerbates this gap (Hurtado-Mazeyra et al., 2025; Ncube, 2026; Suh & Jeun, 2025).

Therefore, strategic efforts are required to address the competency gap of ECE teachers in technology-based learning through comprehensive digital literacy enhancement. Professional development initiatives should focus not only on technology use but also on the development of contextual and sustainable technology-based instructional design competencies. Practice-based training, collaborative support, and the use of systematic digital competency evaluation frameworks are essential steps in improving the quality of technology-based learning ( elik et al., 2026; Kewalramani et al., 2025; Rui et al., 2025; Silva-Quiroz et al., 2025). Accordingly, this study is important to analyze the competency gap of ECE teachers from a digital literacy perspective, particularly between technology use and instructional design, as a basis for developing future teacher competency improvement models.

METHOD

This study employed a quantitative approach using a cross-sectional survey design to analyze the competency gap of early childhood education (ECE) teachers in technology-based learning, particularly between technology use and instructional design from a digital literacy perspective. This design was selected as it allows for an objective and measurable description of empirical conditions at a specific point in time (Creswell, 2014). The population of this study consisted of ECE teachers, with a sample of 217 respondents selected through purposive sampling, specifically teachers who are actively teaching and have experience in using technology in learning. Data were collected using a Likert-scale questionnaire (1-5).

The research instrument was developed based on digital literacy and educational technology competency frameworks. The instrument was tested for validity using product moment correlation and for reliability using Cronbach's Alpha, with a reliability threshold of $\alpha > 0.70$ (Hair et al, 2019). Data analysis was conducted using descriptive statistics, including

mean, standard deviation, and percentage, to identify the level of teachers' competencies. In addition, gap analysis was performed to compare scores across dimensions, particularly between technology use and instructional design competencies. The interpretation of results was based on Likert scale categories to determine competency levels (Sugiyono, 2019). This analysis was further supported by the conceptual framework of digital literacy and the Technological Pedagogical Content Knowledge (TPACK) model to explain the integration of technology in learning (Herring et al., 2016).

RESULT AND DISCUSSION

1. Instrument Validity and Reliability

The validity of the research instrument was tested using the product moment correlation technique. The results indicate that all questionnaire items have correlation coefficients higher than the r-table value, confirming that all items are valid and appropriate for use in this study. Furthermore, reliability testing was conducted using Cronbach's Alpha, yielding a coefficient value of: $\alpha = 0.964$. This value indicates that the research instrument has a **very high level of reliability** ($\alpha > 0.70$), demonstrating strong internal consistency and confirming that the instrument is reliable for accurately measuring teachers' competencies.

2. Level of Teacher Competency

Based on the analysis of data from 217 respondents, the findings provide an overview of early childhood education (ECE) teachers' competencies in technology-based learning across six dimensions: creating (design), using, managing, evaluating, learning system, and professionalism. Overall, the results indicate that teachers' competency levels fall within the **moderate category**, with an overall mean score of **Mean = 2.55**. This finding suggests that teachers possess basic competencies in using technology; however, they have not yet optimally developed comprehensive technology-based instructional practices.

3. Results by Dimension

Table 1. Mean Scores of ECE Teachers' Competencies in Technology-Based Learning

No	Competency Dimension	Mean Score	Category
1	Creating (Instructional Design)	2,46	Moderate
2	Using (Technology Use)	2,60	Moderate
3	Managing (Learning Management)	2,57	Moderate
4	Evaluating (Assessment and Evaluation)	2,59	Moderate
5	Instructional System	2,54	Moderate
6	Professionalism	2,51	Moderate

As shown in the table, all dimensions fall within the moderate category, with relatively minimal variation in mean scores.

4. Competency Gap Analysis

The results of the gap analysis indicate a difference between the technology use dimension (using) and instructional design (creating). The mean score for using is 2.60, while creating is 2.46, resulting in a gap of 0.14. These findings indicate that teachers are more proficient in using technology than in developing technology-based instructional design.

5. Item-Level Findings

The item-level analysis reveals a clear pattern in teachers' competencies. The highest mean scores are associated with teachers' perceptions of the benefits of technology in learning ($M \approx 2.85-2.86$), indicating that teachers generally hold positive attitudes toward the integration of technology in educational contexts. This suggests that, at the attitudinal level, teachers are receptive to and recognize the value of technology in enhancing learning processes. In contrast, the lowest mean scores are found in items related to instructional design competencies, including designing learning models, structuring instructional sequences, and developing technology-based learning systems ($M \approx 2.42-2.43$). These findings highlight a critical weakness in teachers' ability to translate technological knowledge into pedagogically meaningful

instructional practices. Moreover, the analysis of negative (reverse-coded) items shows relatively low mean scores ($M \approx 1.49\text{--}1.54$), indicating that a proportion of teachers still experience difficulties and lack confidence in designing and managing technology-based learning environments. This reflects underlying issues related to self-efficacy and pedagogical readiness, which may hinder effective technology integration.

6. Summary of Findings

Overall, the findings indicate that early childhood education (ECE) teachers' competencies in technology-based learning are at a moderate level. Teachers demonstrate higher proficiency in technology use compared to instructional design. The results also reveal a clear competency gap between the operational and pedagogical aspects of teachers' digital literacy. Furthermore, the primary weakness lies in teachers' ability to systematically design technology-based instruction, highlighting limitations in translating technological skills into effective pedagogical practices.

This study offers a novel contribution by explicitly examining the competency gap between technology use and instructional design among early childhood education (ECE) teachers from a digital literacy perspective. While previous studies have explored digital competence in general, limited research has specifically focused on the imbalance between operational and pedagogical competencies in technology-based learning within the ECE context. By highlighting this gap, the present study provides a more nuanced understanding of how digital literacy manifests in instructional practice, particularly in distinguishing between technology use and instructional design.

The findings indicate that ECE teachers' competencies in technology-based learning remain at a moderate level (mean = 2.55), with higher proficiency in technology use than in instructional design. This result confirms the existence of a gap between the operational and pedagogical dimensions of teachers' digital literacy. Conceptually, digital literacy extends beyond technical skills and includes higher-order competencies such as critical thinking, creativity, and the ability to design meaningful learning experiences (Ghosh & Kumar, 2026; Manditereza et al., 2026; Ncube, 2026). However, the findings suggest that teachers' competencies are still concentrated at the operational level and have not yet advanced to the levels of creation and integration.

These findings are consistent with prior research indicating that technology in early childhood education is often used in a substitutive manner without substantial pedagogical redesign (Nurhayati & Judijanto, 2025, 2026; Wang, 2024). Similarly, Hurtado-Mazeyra et al. (2025) and Ncube (2026) reported gaps in digital teaching competence, particularly in higher-order skills such as instructional design and integration. However, this study extends previous findings by explicitly quantifying the gap between technology use and instructional design, thereby providing empirical evidence of the imbalance between operational and pedagogical competencies.

The similarities between this study and previous research may be attributed to common structural challenges, such as limited professional development opportunities, insufficient emphasis on instructional design in training programs, and constraints in educational infrastructure. At the same time, differences in findings across studies may be influenced by contextual factors, including variations in educational systems, socio-cultural contexts, and teachers' prior experiences with technology integration. For instance, in contexts where teacher training emphasizes pedagogical integration, the gap between technology use and instructional design may be less pronounced.

From the perspective of the Technological Pedagogical Content Knowledge (TPACK) framework, the findings indicate that the integration of technology, pedagogy, and content has not yet been fully achieved. Teachers who possess technological skills without corresponding pedagogical competencies tend to use technology in a fragmented and non-systematic manner (Dewi et al., 2025; Herring et al., 2016; Lim, 2023). This study contributes to the literature by reinforcing the importance of integrative competencies and by demonstrating that the key challenge in digital literacy lies not in access or basic use, but in the ability to design meaningful and contextually relevant learning experiences.

Furthermore, this study contributes to the field by positioning instructional design as the critical dimension in digital literacy development among ECE teachers. While many studies emphasize technology adoption, this research highlights the need to shift focus toward pedagogical integration. In doing so, it fills an important gap in the literature and provides a clearer framework for understanding teacher competencies in technology-based learning.

The implications of these findings are both practical and theoretical. Practically, there is a need for comprehensive professional development programs that emphasize instructional design, practice-based learning, and collaborative approaches. The integration of frameworks such as DigCompEdu can support systematic competency development and enhance teachers' ability to integrate technology effectively (Çelik et al., 2026; Kewalramani et al., 2025; Kim et al., 2025; Rui et al., 2025; Silva-Quiroz et al., 2025). From a theoretical perspective, this study reinforces digital literacy as a multidimensional construct and supports the relevance of integrative frameworks such as TPACK in understanding technology integration.

Future research should explore intervention-based approaches to improving instructional design competencies, as well as investigate how contextual factors such as policy, institutional support, and cultural practices influence technology integration in early childhood education.

CONCLUSION

Based on the findings, it can be concluded that early childhood education (ECE) teachers' competencies in technology-based learning are at a moderate level, with higher proficiency in technology use than in instructional design. These findings reveal a clear competency gap between the operational and pedagogical dimensions of teachers' digital literacy. While teachers are generally capable of using technology as a supporting tool in learning, they have not yet been able to systematically integrate it into comprehensive and meaningful instructional design. This indicates that teachers' digital literacy remains at a basic level, focused on technology use, and has not yet advanced to higher levels such as creation, evaluation, and integration. The identified gap highlights that the primary weakness lies in teachers' instructional design competencies, including the ability to design technology-based learning models, structure instructional sequences, and systematically integrate learning objectives, activities, and evaluation. Therefore, efforts to strengthen teacher competencies should not be limited to technical skills in using technology but should also emphasize the development of pedagogical competencies and contextually relevant technology-based instructional design aligned with the characteristics of early childhood learners.

The implications of this study suggest that professional development programs for ECE teachers need to be designed more comprehensively, emphasizing practice-based training, continuous mentoring, and the strengthening of instructional design competencies. In addition, institutional support is essential, including the provision of infrastructure, policies that support technology integration, and the development of teacher learning communities to enhance digital literacy competencies sustainably. From a theoretical perspective, this study reinforces the importance of digital literacy as a multidimensional competence encompassing technical, pedagogical, and creative aspects, as well as the relevance of integrative frameworks such as TPACK in explaining teachers' ability to effectively integrate technology into teaching and learning.

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