Enhancing Early Childhood Teachers' Digital Competence: Policy Strategies and Implementation Challenges in Eight European Union Member States

Ning Hu, Noor Syamilah Zakaria and Maizatul Mardiana Harun

Abstract –**With education rapidly transforming due to digital developments, members of the European Union have begun to implement extensive policy schemes to improve the digital capabilities of those teaching very young children. This article reports an examination of these policy initiatives, based on the policy documentation proposals of European Union members, intended to augment the digital competencies of these early childhood educators. A qualitative design was utilized to analyze nine sets of policy documentation from the equivalent number of EU countries, published from 2015 to 2025. Using the European Framework for the Digital Competence of Educators (DigCompEdu) as a foundation, the chosen policy documents were analyzed with the guidance of a specifically created coding manual. According to the findings, the digital competencies of these educators have been strengthened principally via three key processes. These are professional growth and assistance from institutions; establishing platforms containing nation-level digital resources; and ensuring that digital technology is integrated innovatively into the education and care of young children. In this study, the implementation of these policies was revealed to encounter related difficulties and limitations. Utilizing experiences of these policies, advice is offered to nations aiming to enhance the digital capabilities of educators in preschool settings. Practical implications are suggested regarding the implementation of digital policies, mechanisms to assist educators, and ethical administration in the early childhood educational context.**

Keywords – **Early childhood education; Teacher digital competence; European Union policy; Digital education strategy**

I. INTRODUCTION

The education field is transforming due to major digital developments and in a rapidly globalizing and digitalizing context. With digital technologies being used to extensively, traditional ways to approach teaching are changing, while openings are being created to make education more equitable, individualize learning, and enhance the quality of instructions. A key factor in improving preschool education in terms of access and quality is the implementation of digital approaches to learning. Since early childhood teachers play a major role in reforming education, their digital competencies have a direct influence on whether teaching practices effectively deploy digital technology (You & Yu, 2025). To promote a more digitalized education system, reasonably comprehensive policy mechanisms and considerable practical experience are evident in the European Union (EU). More specifically, the European Commission issued the Achieving the European Education Area by 2025 Communication. This highlights how digital transformation in education creates various demands; to address these, the paper urges stronger digital competencies and pedagogical capacities among teachers. Moreover, EU members are recommended to boost the classroom application of technology by educators with the establishment of effective systems of training for teachers (European Commission, 2020). In addition, the Digital Education Action Plan (2021-2027), issued by the European Commission (2020), clearly states the digital competency development of teachers as one of its core objectives. The plan also promotes continuous professional development through cross-border cooperation, online training platforms, and teacher communities.

The concept of digital competence has been variously defined in the literature over the past decade. A Recommendation of the European Parliament and of the Council of the European Union (2006) defines digital competency as the "confident and critical use of Information Society Technologies for work, communication, and leisure." Building upon this understanding, Ferrari (2013) further characterizes digital competence as the ability to use technology to effectively optimize our daily lives. The connotation of digital competence has since expanded to include various dimensions such as information recognition, communication and collaboration, content creation, security awareness, and technical problem-solving (Vuorikari et al., 2022). Various national teacher digital competence frameworks emphasize that these competencies encompass both the technical level required by teachers and the necessary pedagogical knowledge (McGarr & McDonagh 2021). Specifically, these involve not only the technical skills linked to using digital tools in daily teaching but also comprehensive literacy, which is required to effectively integrate digital technology into teaching, assessment, and teacher-student interaction. In early childhood education (ECE), however, the digital competence of teachers entails more distinctive challenges. They must understand the principles of childrens' development, select digital resources and tools, support children's holistic development, and establish effective digital communication with both the parents and the wider educational environment (Falloon, 2020).

II. LITERATURE REVIEW

Existing Research on the Digital Competence of Teachers

Previous research on the digital competence of early childhood teachers has mainly focused on two directions. One strand focuses on the individual level, examining the technology acceptance, levels of digital competence, and

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self-efficacy of teachers. The other evaluates the effectiveness of teacher training courses, digital workshops, and continuing professional development programs from the perspective of teacher professional development. In one example of individual-level research, Gudmundsdottir and Hatlevik (2017) conducted a national survey of 356 new teachers finding that their self-efficacy in teaching and learning was significantly positively correlated with their actual application of ICT. Similarly, Blackwell et al. (2014) confirmed the mediating role of teachers' subjective beliefs in the process of technology adoption. This study showed that teachers' attitudes toward the value of technology education were the strongest predictors of the frequency of technology use, followed by self-efficacy and external support. Based on these examinations of samples from a variety of countries and sets of participants, this research suggests that, overall, digital competencies among educators in early childhood and pre-service settings depend on a range of factors. These include technical capabilities, attitude, self-efficacy, and views on how valuable digital technologies are.

Furthermore, the digital competencies of early childhood educators were measured using a questionnaire created and validated by Romero-Tena et al. (2025). The outcome was their proposal for a digital competency framework containing five dimensions: informational literacy, communicating and collaborating, the creation of digital content, security, and solving problems with technical aspects. Meanwhile, a sequential mixed-methods design was applied by ElSayary (2023), who combined data obtained quantitatively and qualitatively to explore how the progress of digital competencies among educators was impacted by a training course. The results showed that training programs could effectively improve the digital skills of teachers. These studies reflect two major current trends in research on digital competence: firstly, a focus on teachers' perceptions and competence measurement and, secondly, an emphasis on understanding the development of teachers' digital competence from both a psychological and a behaviour al perspective. Meanwhile, empirical evaluations have highlighted the key role of professional development training in strengthening digital competence among educators.

Research Gap

Despite some studies having extensively discussed teachers' digital competence, some shortcomings remain in the existing literature. First, most relevant studies focus on evaluations of teacher training programs, curriculum interventions, or the effects of technology use, while institutional support mechanisms for teachers' digital competency development have rarely been examined from the perspective of education policy. Secondly, more attention has been directed to ordinary primary and secondary school teachers or pre-service teachers, with relatively limited attention paid to those teaching early childhood education. From the perspective of multi-country comparison in particular, there remains a lack of systematic sorting and analysis of digital competency development policies for preschool teachers. To a certain extent, this limits any in-depth understanding of different national policy paths, support priorities, and their common characteristics. It also makes it difficult to provide more targeted policy enlightenment for digital capacity building among ECE teachers.

Given the shortcomings outlined above, this study focuses on policies related to digital competence in early childhood teachers in EU member states, adopting the Digital Competence of Educators (DigCompEdu) as the analytical framework. The EU has established a systematic framework for digital education governance, and it continues to prioritize the enhancement of teachers' digital capabilities as a critical aspect of education transformation. Consequently, analyzing the relevant EU policies would enhance the comprehensiveness of the policy support paths followed to promote the digital competence of preschool educators. It would also provide theoretical insights and practical guidance for nations advancing the development of digital literacy systems for preschool teachers.

DigCompEdu as the Analytical Framework

This study is guided by the European Framework for the Digital Competence of Educators (DigCompEdu), which was developed by the European Commission's Joint Research Centre as a comprehensive reference framework for digital competence among educators. DigCompEdu divides this concept into six interrelated areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence (Redecker, 2017). Based on these six aspects, the digital capability of educators encompasses their engagement with the profession, making pedagogical decisions, practices of assessment, and supporting students in digitalized media environments (Tzafilkou et al., 2023; Kiryakova & Kozhuharova, 2024). DigCompEdu moves past focusing narrowly on ICT abilities to highlight other teacher behaviour s, including the employment of digital technology in their pedagogy, reflective practices, and student-oriented factors. Overall, DigCompEdu reflects a wider comprehension of the effectiveness with which educators can operate in highly digitalized educational settings. The framework emphasizes that educators should be able to select and adapt digital resources, design digitally supported learning activities, implement digitally enabled instruction, use digital means to assess learning, and foster the ability of students to use digital technologies responsibly and creatively.

Thus, DigCompEdu offers a dedicated analytical framework with which to undertake comparisons of national policies. It also guides the coding and categorization of texts, which primarily explained why it was used in the current research. Moreover, the framework allows more systematic cross-domain examinations of the ways in which the digital competencies of teachers are supported by policy documentation, as well as revealing possible potential disparities in these policies. In general, DigCompEdu enables the digital competencies of teachers to be better understood by providing a conceptual basis for this. It also represents a robust foundation for analyzing the range, emphasis, and drawbacks of policy support in the education of preschoolers. Figure 1 illustrates the DigCompEdu framework, showing the six areas of competency, the coding procedure, and how the eventual themes were classified.

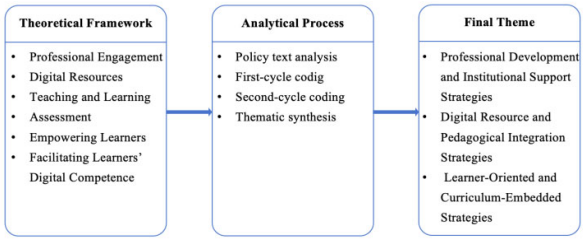


Figure 1. Analytical framework of the study, based on DigCompEdu

Research Questions

The following research questions were proposed:

RQ1: In the European Union and its member counrties, which policy approaches and implementation systems have been implemented to improve the digital competencies of early childhood educators?

RQ2: While implementing these policies, which major issues and obstacles have been met, and how can these problems inform the development of mechanisms for early childhood teaching in settings beyond the EU?

III. METHOD

In the current work, policy texts were qualitatively analyzed to explore which approaches and means of implementation have been deployed by countries in the EU to improve digital competencies among early childhood teachers. Policy text analysis is a systematic approach for examining and interpreting printed and digital documents, allowing researchers to discern meanings, classify information, and recognize trends within policy texts (Bowen, 2009).

Data Collection

Given the large number of policy texts in the EU member states and the differences in document types, language availability, and policy coverage, a full sample was not used in this study. Instead, eight countries were selected: Germany, France, Sweden, Finland, Spain, Italy, Ireland, and Estonia. This purposive case selection balanced the feasibility of the study against the diversity of policy contexts and the availability of documentation. Documents were selected based on three criteria. First, the policy documents were published between 2015 and 2025, that is, after the publication of DigcompEdu. Second, the documents were issued or endorsed by national education authorities or EU-level institutions, and they included strategies, action plans, competence frameworks, and official guidance. Finally, the documents were available in English or had official English translations. Priority was given to policy documents that explicitly addressed early childhood education (ECE). If a dedicated ECE document was unavailable at the national level, ECE had to be included in the broader digital education strategy.

Data Analysis

A deductive qualitative content analysis method was used. NVivo 15 software was used to assist with text extraction and categorization. Relevant text segments were extracted from the policy documents, including elements related to the digital competencies, professional development support, digital resources, digital teaching, evaluation, and digital competency development of early childhood teachers. The extracted segments were organized according to the six domains of the DigCompEdu framework, with the recurring subthemes further refined through iterative comparison. The second cycle of coding reorganized and regrouped these subthemes, resulting in three overarching themes. Based on these themes, analysis was undertaken of the core strategies, implementation mechanisms, and support pathways adopted by the nine EU member states to enhance the digital competence of early childhood teachers. Additionally, the challenges and limitations associated with policy implementation were analyzed.

IV. FINDINGS

The policy texts of the EU countries were analyzed, which indicated that these states have created various interconnected policy approaches to enhance digital competencies among educators in early childhood settings. The main focus of these elements is support for professional development, the supplying of digital resources, integrating practices into the classroom, and orienting strategies around the empowerment of learners.

Theme 1. Professional Development and Institutional Support Strategies

Two widely utilized policy measures were identified: the ongoing enhancement of professionals and the construction of networks for professionals to collaborate. Policy documents emphasize the enhancement of digital engagement and professional growth among early childhood teachers through the organization of digital competency training, peer learning, and collaboration with early education institutions. The French Digital Strategy for Education (2023–2027) proposed enhancing digital engagement in teaching among ECE educators through technical support, online training resources, and networked professional learning (France, MNEY-DE 2023–2027, 2023, p. 28). Germany's Digital Media in Early Childhood Education requires preschool institutions to formulate independent media use plans. The scheme also encourages teacher teams to undertake joint reflection and decision-making related to educational goals and digital media integration (Germany, MEYS-MBJS, 2023, 6.1, p. 19). This ensures that early childhood educators can continue their learning without incurring an administrative burden. Finland has provided a long-term platform for professional exchange among early childhood teachers through the establishment of discussion forums on media education and the provision of continuous guidance and information (FNAE, MEC-MLF, 2019, p. 14, p. 52). Spain's España Digital 2026 also identifies digital skills training as a national priority (Spain, Espana Digital 2026, P 15).

Theme 2. Digital Resource and Pedagogical Integration Strategies

Another important strategy is the development of national-level digital resource platforms to create supportive environments for teaching and learning. France has built a unified national digital education platform system that integrates open data, collaborative spaces, and digital educational services through a "platform state" model, thereby enabling teachers to access, create and share high-quality digital teaching resources (France, MNEY-DE 2027, 2023, p. 25). Sweden has emphasized the use of emerging digital technologies to establish secure network infrastructures and ensure that early childhood teachers can use digital tools reliably (Sweden, SNAE-NDSS, 2022, p. 12). In Italy, the Ministry of Education, Universities and Research (MIUR) promoted the Curricoli Digitali project through the National Digital School Program (PNSD) (Italy, MIUR, 2024, P 15). Through this project, a website was created to provide digital teaching solutions and practical examples of STEM activities for ECE. Additionally, the integration of digital tools into teaching and learning practices emerged as a common core promotion strategy. France emphasizes improved training of education teams in digital teaching and promotes the purposeful use of digital technologies by teachers before, during, and after teaching through peer support, learning communities, and teaching guidebooks (France, MNEY, 2023). Germany has provided time and funding for team-based training, technical discussions, and digital pedagogy consultations, and a website has been developed to support teachers and children in active media practices (Germany,MEYS-MBJS, 2023, p. 39). Spain has integrated the development of teacher digital skills into its national digital strategy (Spain, Espana Digital 2026, p. 22).

Theme 3. Learner-Oriented and Curriculum-Embedded Strategies

These eight countries were generally found to apply three strategies that encourage preschool teachers to empower and foster digital competence among learners: value-based framework guidance, curriculum-system embedding, and project-based support. Spain's national strategy, Digital Spain 2026, states that digital transformation should be humanistic, inclusive, and people-centered, thereby establishing a clear ethical framework for the participation of teachers and learners in digital education (Spain, España Digital 2026, 2021, p. 22). Complementing this vision, Spain has provided legal and ethical references for ECE teachers to use in designing digital learning experiences through the Charter of Digital Rights (Spain, España Digital 2026, 2021, p. 18). Sweden, by contrast, links digital competence to lifelong learning, equality, and gender equality (Sweden, SNAE-NDSS, 2022, pp. 7, 11). Germany has translated the critical, creative, and responsible use of media into concrete teacher support programs through partnerships with libraries, media education programs, and support initiatives at the federal and state levels (Germany, MEYS-MBJS, 2023, 8.1; Germany, MKJFGFI-NRW, 2019, P. 22, P. 73). Compared with the broader humanistic frameworks of Spain and Sweden, Germany's policy represents a more practice-oriented effort to translate ethical principles into concrete teacher support programs and teaching resources. In Ireland, the Digital Strategy for Schools to 2027 established a Standard Minimum Digital Skills Framework for Teachers and Learners, the goal being to ensure that all educators and students had a common foundation in digital literacy (Ireland, DE-DSS, 2022, p. 37-40). The strategy further calls for curriculum reform to integrate digital skills into everyday classroom practice and promote student-centered learning through digital archives (Ireland, DE-DSS, 2022, pp. 39-40). As a complement to the curriculum-focused measures taken by Ireland, digital competencies are regarded in Sweden as long-term educational requirements that link to the training of teachers and assessments in schools (Sweden, SNAE-NDSS, 2022, p. 7). Through this national policy, the logic has been expanded to integrate digital competencies into educational routes across the entire system. Illustrated via such approaches are the ways in which ECE teaching is supported by a national policy that aims to attain learner empowerment within teacher training and a curriculum framework.

V. DISCUSSION

According to the results of this study, the focus of the eight European Union (EU) member states is the integration of the digital competencies of early childhood education (ECE) teachers into frameworks of ongoing professional development. Across the nine countries, there is a general recognition that enhancing these abilities among such educators depends not simply on one-off training; pre-service and in-class training must incorporate these improvement measures (Masoumi & Noroozi, 2023). That is, instilling in ECE teachers the necessary digital competencies must be regarded as one element of a multi-level approach to the management of education, not as a singular matter of training. In such systems, the vital nature of pre-service training for ECE educators is regularly highlighted in the policy documentation. Information technology courses in teacher education can significantly enhance the digital skills of pre-service teachers and strengthen their ability to design digital learning materials for early childhood settings (Romero-Tena et al., 2020; Dogan and Gogus, 2025). The development of this competence relies heavily on an accessible, actionable, and educationally relevant resource environment, rather than solely on the spontaneous exploration of individual teachers (Madsen et al., 2023).

Additionally, the findings reveal that national online resource platforms and the provision of digital resources have become common policy measures. This suggests that EU countries attach considerable importance to, firstly, the accessibility of digital governance strategies in early childhood education and care (ECEC), and secondly, enhancing the quality of ECEC through improved digital resources and educator training. Although ECE teachers generally display positive attitudes toward learning digital technologies, many do not enter the profession with sufficient preparation to integrate these technologies effectively into their teaching practice (Casillas Martín et al., 2019). In fact, in-service ECE teachers are more inclined to strengthen their digital skills through short-term online

training courses (Leoste et al., 2019). From this perspective, national online digital resource platforms can lower barriers to access, expand the scope of training, and provide diversified models of online digital skills development for preschool teachers. These policies indicate that the integration of digital technology into ECEC pedagogy processes is not simply a matter of using "smart devices", but of aligning technology use with pedagogical goals. This would support children's holistic development and foster their emerging digital thinking. Similarly, Lähdesmäki et al. (2023) argued that digital pedagogy should be embedded in the core practices of play-based learning in kindergartens, thus providing a foundational framework for digital learning in ECEC.

Furthermore, the findings of this study suggest that some policies have begun to move beyond a narrow focus on "technology provision" or on whether teachers can use digital tools. Instead, they increasingly emphasize that digital technology in ECEC should support children's holistic development, learning participation, and developmentally appropriate practice. More specifically, truly effective digital support must respond to the development characteristics of children's digital literacy and be embedded in both the curriculum and the everyday logic of teaching. In the preschool years, the value of digital technology lies in its capacity to support children's cognitive development, language development, social interaction, and active exploration (Baikulova et al., 2024; Clemente-Suárez et al., 2024; Brinck et al., 2023). Digital practice in ECEC cannot simply be modeled on that of primary and secondary schools or on general digital education policies; instead, it must be grounded in developmental appropriateness, play-based learning, and the meaningful participation of children (Undheim, 2022; Otterborn et al., 2023).

VI. CONCLUSION AND LIMITATION

Policy document analysis was conducted to explore the digital competence of ECE teachers in eight EU member states. The findings indicate that EU policies have expanded the digital competence of early childhood teachers from a single technology application to a comprehensive competence covering professional development, resource support, teaching integration, and governance mechanisms. Countries have promoted relevant policies primarily by building digital platforms, integrating digital education into early education curricula, and deploying multi-level management. However, deficiencies remain in assessment mechanisms, ECE adaptability, and digital ethics support. This study is also subject to certain limitations. First, the research method was limited, since the results of policy text analysis can only reflect policy intentions, so the actual implementation of policy by teachers in practice cannot be explored using these texts. The second limitation concerns the sample. Only eight EU member states were covered, which does not fully represent the range of differences across the EU. Finally, using DigCompEdu as an analytical framework may have improved the research systematization but it might also have weakened the policy characteristics outside the framework. One potential outcome of this is an overly narrow understanding of the digital competencies that are essential for ECE beyond the scope of the framework, such as the critical thinking, creativity, and collaboration skills that are necessary for holistic child development. In the future, mixed-methods research such as interviews, questionnaires, or case studies could be applied to further examine how policies are implemented at kindergarten level. Comparative studies might also reveal the similarities and differences between EU and non-EU countries in terms of digital capacity building for early childhood teachers. This would provide the basis for a more contextually adaptable policy design.

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