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Teacher's Digital Competence in Designing Effective Cyber Pedagogy

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ABSTRACT

Digital transformation in education requires teachers to not only be able to use technology, but also to have pedagogical competence in designing digital learning that is interactive, adaptive, ethical, and student-centered. This study aims to systematically examine teachers' digital competence in designing effective cyber pedagogy. The method used is a Systematic Literature Review by reviewing relevant international articles on teachers' digital competence, digital pedagogy, and cybergogy. The results of the study show that teachers' digital competence is a multidimensional construct that includes technical, pedagogical, informational, communicative, ethical, and professional abilities. These competencies play an important role in the selection of digital learning resources, the management of online interactions, technology-based assessments, as well as empowering students in a digital environment.In addition, the development of teachers' digital competencies requires continuous support through training, modeling technology use, institutional support, and professional communities. However, its implementation still faces challenges in the form of infrastructure gaps, variations in teacher readiness, as well as the weak connection between teachers' digital competencies and the operational design of cyber pedagogy

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A. INTRODUCTION

Approved Training Organizations (ATOs) play a critical role in aviation education, tasked with developing licensed aviation professionals who meet international competency standards. In the Philippines, these institutions operate under the regulatory authority of the Civil Aviation Authority of the Philippines (CAAP), which implements national aviation policy in alignment with the standards set by the International Civil Aviation Digital transformation in education has changed the way teachers design, implement, and evaluate learning.

This change no longer positions technology merely as a tool, but as part of a pedagogical ecosystem that requires teachers to have digital competence, the ability to select digital learning resources, manage online interactions, conduct technology-based assessments, and guide students to use technology ethically and productively. The DigCompEdu framework emphasizes that educators' digital competence encompasses six main areas, namely professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. In line with this, the OECD highlights the importance of standards, continuous professional development, and a support ecosystem so that teachers can adapt to the digitalization of education.

In this context, the concept of cyber pedagogy or cybergogy becomes relevant

because digital learning requires a pedagogical design that not only transfers face-to-face learning to online spaces, but also builds interactive, collaborative, reflective, and learner-centered learning experiences. Cyber pedagogy demands that teachers are able to integrate technology with learning strategies, student characteristics, curriculum objectives, assessment, and digital ethics. Therefore, teachers' digital competence needs to be understood as a complex pedagogical competence, not merely technical ability to use digital devices. UNESCO, through the ICT Competency Framework for Teachers, also places pedagogy, curriculum, assessment, application of digital skills, learning organization, and teachers' professional development as important components in the utilization of educational technology.

Previous research shows that teachers' digital competence is a multidimensional construct closely related to pedagogical, professional, ethical, and technological abilities. Falloon (2020) emphasizes that teachers' digital competence must be understood holistically, encompassing technical, information, communication, ethics, security aspects, and the ability to develop meaningful learning. Fernández-Batanero et al. (2022) found that digital competence is important for teachers' professional development, particularly in learning innovation and the effective use of technology. Lucas et al. (2021) indicate that teachers' digital competence is influenced by personal and contextual factors, while Tzafilkou et al. (2023) developed an instrument to measure teachers' digital competence in pedagogical and professional aspects. Smestad et al. (2023) also emphasize that research on teachers' digital competence is increasingly developing, especially before and during the COVID-19 pandemic. but still requires a clearer dimension mapping.

Other research findings emphasize that strengthening teachers' digital competence requires ongoing, contextual, and adaptive training. Masoumi and Noroozi (2025) found that novice teachers need systematic support to develop professional digital competence in actual teaching practice. Pongsakdi et al. (2021) demonstrated that digital pedagogy training can improve teachers' attitudes toward digital technology and reduce their need for technical support. Tondeur et al. (2021) emphasized that digital competence development for prospective teachers cannot use a uniform approach but must be tailored to teachers' needs and readiness levels. Momdjian et al. (2025) showed that there is a digital competence gap between pre-service and in-service teachers based on the DigCompEdu framework. Shi et al. (2025) added that professional development in digital pedagogy can enhance teachers' competence, self-efficacy,and the work welfare of teachers in inclusive education post-pandemic.

In relation to cyber pedagogy, several studies indicate that the effectiveness of digital learning is largely determined by teachers' ability to design technology-based learning experiences pedagogically. Asad and Malik (2023) explain that cybergogy plays a role in developing technology-based learning that emphasizes the cognitive, social, and emotional dimensions of learners. Wong and Moorhouse (2021) found that language teachers in primary and secondary schools use digital competence to overcome online learning challenges through digital resources, teaching strategies, assessment, and student empowerment. Bentri et al. (2022) show that primary school teachers' digital pedagogical competence is influenced by creative ability, the use of learning strategies, and technological support. Waryanto et al. (2025) demonstrate that a cybergogy model can be used to classify teachers' digital pedagogy profiles and support sustainable educational innovation. Timotheou et al. (2023) also found that the integration of digital technology impacts not only student learning outcomes but

also teacher practices, inclusion, school capacity, and educational transformation.

Based on the results of these studies, it can be interpreted that the literature on teacher digital competence has developed strongly in aspects of definition, measurement, and professional development, but has not fully mapped how these competencies are translated into effective cyber pedagogy design. Some studies still separate digital competence as a teacher's ability, while studies on cybergogy focus more on technology-based learning and student engagement. Thus, there is a gap in the integration between teacher digital competence and cyber pedagogy design, particularly concerning how teachers select digital resources, manage online interactions, conduct digital assessments, facilitate collaboration, maintain digital ethics, and create adaptive and inclusive learning. The novelty of this SLR is synthesizing previous research to produce a conceptual map of the dimensions of teachers' digital competence that most contribute to the design of effective cyber pedagogy.

This study aims to systematically examine how teachers' digital competencies are conceptualized, developed, and implemented in the design of effective cyber pedagogy. This review is directed to answer several main focuses, namely: which dimensions of digital competence are most relevant for teachers in designing cyber pedagogy; how strategies for developing teachers' digital competencies are carried out; what factors support and hinder the implementation of cyber pedagogy; and what conceptual model can be offered to link teachers' digital competencies with effective digital learning design. Thus, this SLR is expected to provide theoretical contributions to the development of studies on teachers' digital competencies and practical contributions for schools, teacher education institutions, as well as policymakers in designing teacher professional development based on cyber pedagogy.

B. METHODS

This study uses the Systematic Literature Review (SLR) method to identify, select, analyze, and synthesize previous research results regarding teachers' digital competence in designing effective cyber pedagogy. The review reporting procedure follows the PRISMA 2020 guidelines, which emphasize transparency in the process of identification, screening, eligibility assessment, and article inclusion. PRISMA 2020 provides a 27-item checklist and a flow diagram to help authors report systematic reviews completely and systematically. The research procedure is presented in the following Figure 1.

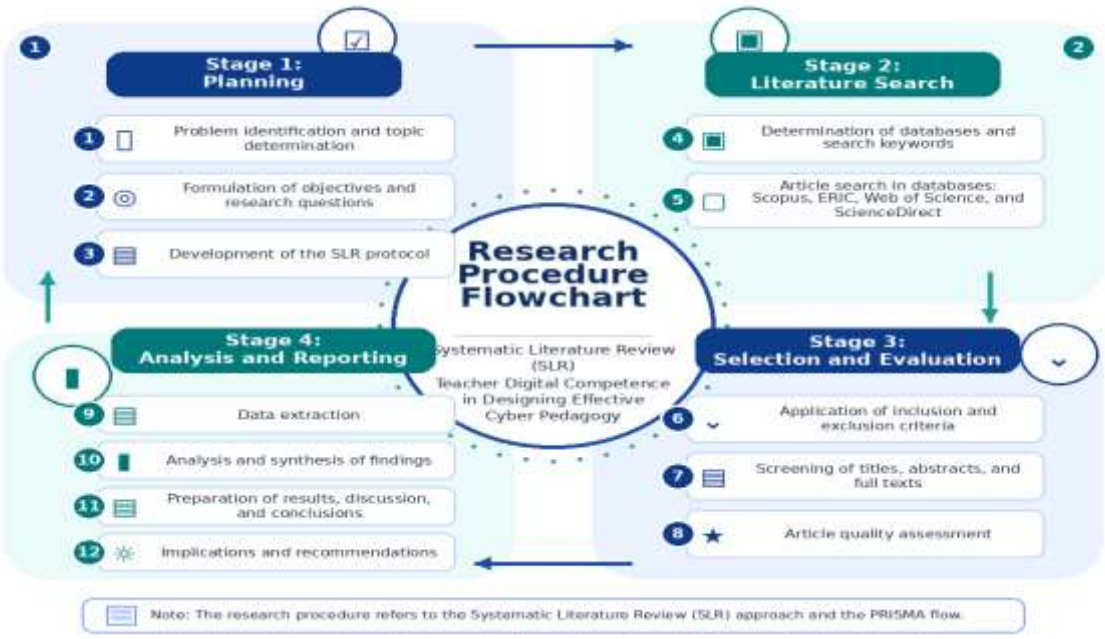


Figure 1. *SLR* research procedure

The data sources in this study were obtained from international journal articles indexed in reputable databases, such as Scopus, Web of Science, ERIC, ScienceDirect, SpringerLink, Taylor & Francis, Emerald, and SAGE Journals. The article selection process was carried out in several stages, namely (1) articles were identified through the specified databases; (2) duplicate articles were removed; (3) titles and abstracts were screened based on relevance to the research focus; (4) articles that passed the initial stage were read in full to determine their eligibility; (5) articles meeting the criteria were further analyzed using a data extraction table.

Data analysis was conducted using a thematic synthesis approach, which involves grouping the findings of the articles into main themes according to the research objectives. The themes analyzed include: dimensions of teachers' digital competence, strategies for implementing cyber pedagogy, supporting and inhibiting factors, and directions for the development of digital learning models.

C. RESULT AND DISCUSSION

The results of the literature synthesis show that teachers' digital competence is a multidimensional construct that is not only related to technical skills in using digital devices, but also includes pedagogical, ethical, communicative, informational, and professional aspects. Falloon explains that teachers' digital competence needs to be understood holistically because teachers are not only required to be able to use technology, but also to guide students to participate safely, productively, and ethically in digital environments. In line with this, Tzafilkou et al. emphasize that teachers' digital competence should be assessed in the context of pedagogical and professional activities, not just based on technical skills. Thus, teachers' digital competence becomes an important foundation in designing meaningful, targeted digital learning that meets students' needs.

The next findings show that teachers' digital competence is closely related to the quality of digital learning practices. Teachers who have good digital competence tend to be more capable of selecting digital learning resources, managing learning interactions, using technology-based assessments, and adapting learning strategies to

student characteristics. Timotheou et al. indicate that the integration of digital technology in schools not only impacts student learning outcomes but also affects teacher practices, school capacity, and education transformation more broadly. This is reinforced by Tondeur et al., who developed a teacher digital competence framework emphasizing the dimensions of teaching practice, empowering students in a digital society, teacher digital literacy, and professional development.

The study results also indicate that the development of teachers' digital competence requires continuous support. Digital competence cannot be built through short, technical training, but needs to be developed through ongoing professional learning, modeling of technology use by educators, institutional support, and communities of practice. Lindfors et al. found that the development of professional digital competence in teacher education requires educators to act as digital models, support in instructional design, and the integration of technology into teacher education practice. Abedi et al. also showed that prospective teachers benefit from educational technology courses, modeling of technology use by lecturers, and practical experiences that provide opportunities for technology integration in learning.

In the context of cyber pedagogy or cybergogy, the synthesis results show that effective digital learning must be designed to be interactive, collaborative, and oriented towards learner engagement. Asad and Malik explain that cybergogy is a technology-based learning paradigm that develops within the context of Education 4.0 and aims to build learners' competencies in a virtual environment. Therefore, cyber pedagogy should not be understood merely as the use of digital platforms, but as a pedagogical design that integrates technology, interaction, collaboration, virtual learning experiences, and the development of learners' competencies. In this regard, teachers' digital competence becomes the main foundation so that digital learning is not only administrative in nature but also capable of creating active and meaningful learning experiences.

Nevertheless, the literature also shows a number of challenges in the implementation of teachers' digital competence to design effective cyber pedagogy. These challenges include variations in teacher readiness, limitations in infrastructure, gaps between measured competencies and actual classroom practice, as well as the dominance of perception-based or self-assessment instruments. Norhagen et al. found that studies on professional digital competence in teacher education still largely focus on the perceptions of pre-service teachers and teacher educators, thus requiring more diverse and contextual research. In addition, Falloon also emphasizes the need to broaden the understanding of teachers' digital competence so that it does not get trapped in merely the technical dimension.

Discussion

Based on the results of the synthesis, it can be understood that teachers' digital competence is a key prerequisite in designing effective cyber pedagogy. Teachers who possess digital competence are not only able to use digital devices but are also able to determine learning objectives, select relevant media, manage online interactions, conduct digital assessments, and guide students to use technology critically and responsibly. Thus, effective cyber pedagogy requires an integration of technological competence and pedagogical competence. This finding aligns with Falloon, who emphasizes the importance of a holistic understanding of teachers' digital competence, as well as Timotheou et al. (2023), who show that digital technology has a broad impact on educational practice and school transformation.

Pedagogically, the results of this study emphasize that the design of cyber pedagogy cannot be separated from the teacher's ability to create interactive, adaptive, and student-centered learning. In digital learning, teachers need to be able to facilitate online communication, collaboration, differentiated learning, the use of digital learning resources, as well as assessments that align with learning objectives.

This discussion also shows that there is still a significant research gap that needs to be further examined. Most studies on teachers' digital competence have focused on measuring abilities, perceptions, or teacher readiness, while studies specifically explaining how these competences are translated into concrete cyber pedagogy design are still relatively limited. In practice, teachers' digital competence should be reflected in pedagogical decisions, such as media selection, the design of online learning activities, interaction strategies, forms of assessment, management of digital ethics, and the empowerment of learners. Therefore, this SLR has the potential to make a scientific contribution by offering a conceptual mapping of the relationship between teachers' digital competence and the key elements of cyber pedagogy.

The novelty of this study lies in the effort to integrate two streams of literature that have often been discussed separately, namely teacher digital competence and cyber pedagogy/cybergogy. Literature on teacher digital competence generally emphasizes the dimension of skills and professional development, whereas literature on cybergogy places more emphasis on the characteristics of digital learning and virtual environments. By connecting the two, this SLR can produce a conceptual model that explains how teacher digital competence contributes to the design of digital learning that is interactive, collaborative, ethical, adaptive, and learner-centered. Future research directions need to empirically test this model across various educational levels and school contexts so that its contribution is not only conceptual but also applicable in educational practice.

D. CONCLUSION AND SUGGESTIONS

factor in designing effective cyber pedagogy. This competence is not limited to technical skills in using digital devices, but also includes pedagogical, ethical, communicative, informational, and professional abilities. Teachers who have good digital competence are better able to choose digital learning media, manage online interactions, develop technology-based assessments, and create active and meaningful learning for students. In addition, effective cyber pedagogy requires learning design that is interactive, collaborative, adaptive, and student-centered. Digital learning is not enough to merely move the learning process to an online platform, but must be designed by considering learning objectives, student characteristics, socio-emotional engagement, digital ethics, and the meaningfulness of the learning experience.

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