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# Technologies in Digital Literacy Training: How Are Collaborative, Seamless, and Online Learning Approaches Utilized?

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**ABSTRACT**

The proliferation of new educational technologies and the shift to blended and fully online learning environments have made digital literacy a critical competency for teachers. In particular, seamless collaborative learning frameworks present challenges due to inequitable access to technology, varying levels of pedagogical practice, and gaps in integration of training with digital literacy instruction. This study focuses on instructors trained in digital literacy with an emphasis on collaboration, seamless learning, and online pedagogy. A total of 15 articles out of a total of 95 retrieved from ERIC were selected based on relevance and established criteria. It was found that Learning Management Systems such as Moodle, Google Classroom, and Blackboard were used to a limited extent to manage course materials including digital content, assignments, assessments, and provide grade feedback. Moreover, collaboration platforms such as Google Docs, Zoom, and Microsoft Teams enhance group discussions and projects. The digital literacy curriculum encompasses a spectrum of skills, from fundamental to advanced, including the utilization of instructional tools, management of digital content, digital security, and proficiency in social media. Mobile gadgets in Bring Your Own Device (BYOD) models facilitate uninterrupted, adaptable learning. Notwithstanding the benefits, access to gadgets and internet connectivity continues to pose a considerable barrier. This study shows that customized digital literacy curriculum can improve educators' skills, however further support is necessary to overcome technological obstacles. Further research is recommended to explore scalable solutions that can bridge these gaps and promote equitable digital literacy training across diverse educational contexts.

**Keywords:** Collaborative learning, Digital literacy training, Educator competence development, Learning Management Systems, Seamless learning

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## INTRODUCTION

The global adoption of all forms of digital technologies into educational systems and frameworks around the world has profoundly transformed teaching and learning. With students' easy access to online platforms, e-resources, and mobile tools in the twenty-first century classroom, the importance of basic digital literacy skills has increased for both teachers and students. Digital "literacy" encompasses one's ability to search, evaluate, and produce a variety of content across a variety of electronic systems that are fundamental in today's hybrid or fully

remote academic environments (Akçıl & Baştaş, 2020; Jimarkon et al., 2021; Paetsch & Drechsel, 2021). This transformation is particularly evident in the context of online and blended learning, where the capacity to collaborate, communicate, and engage meaningfully through digital means is increasingly indispensable (Amin et al., 2023; Kailani et al., 2021). It highlights the urgent need for robust digital literacy competencies to ensure quality in education across diverse contexts.

The increasing adoption of technology in teaching has magnified the need for digital competency among educators and learners. A minimum level of information technology competency is required from educators by educational institutions, not only for professional development purposes, but because they have to actively participate in the ongoing paradigm shift. Education 4.0 faces the challenge of adapting to the rapid changes brought about by modern technologies such as Artificial Intelligence (AI). As stated by Ozkara and Cakir, learning motivation increases in online environments with collaborative learning components due to well-integrated collaborative strategies (Ozkara, 2020). Digital literacy plays a pivotal role in developing critical thinking and communication skills, which are highly valued in 21st-century education (Amin et al., 2023; Kailani et al., 2021).

Implementing basic aspects of information technology facilitates cross-platform collaboration. Research results show that perceived educator competency significantly influences how students evaluate their virtual classroom environment (Männistö et al., 2019). Therefore, instructors' digital competency should be prioritized in order to design broader collaborative teaching strategies. Given the rapid shift towards online learning spaces at all levels internationally across contexts, maintaining active engagement becomes increasingly urgent, compounded cumulatively by the convenience offered through the Internet (Budiman & Syafrony, 2023).

Despite the high interest in digital literacy and collaborative learning, there are too many barriers to overcome when implementing them for use in online learning spaces. The majority of teaching practitioners have low collaboration and digital skills which limit the use of technology in cooperative learning. The minimal interaction associated with online learning environments creates problems for both students' collaborative skills training and for teachers trying to implement efficient digital collaboration (Anshori et al., 2023; Ozkara, 2020). This highlights the need for intensive professional development aimed at equipping educators with strategies on how best to automate digital collaborative learning planning so that meaningful improvements can be achieved in learning outcomes.

A common strategy proposed in several studies is the use of technology to enhance collaboration and digital literacy (Sastre et al., 2022). Männistö et al. showed that digital learning systems such as Moodle enable social interaction and collaboration among learners (Männistö et al., 2019). Frequent use of digital tools appears to increase students' ability and willingness to collaborate, share ideas, and provide constructive feedback, which are forms of digital collaboration

(Soufghalem, 2024). However, effective pedagogical design goes hand in hand with technology to enhance these encounters. Studies such as those by Soufghalem (2024) and Budiman & Syafrony (2023) highlight the impact of collaborative learning on the development of digital literacy skills; however, they do not consider pedagogical design aimed at meaningful collaboration that provides a strong constructivist teaching framework where teaching strategies are weak.

Evidence suggests that digital skill enhancement in collaborative and online learning environments can be enhanced through a systematic approach. Online learning environments foster the development of students' digital literacy, encouraging engagement and collaboration (Khan et al., 2022; Soufghalem, 2024). Furthermore, Abedi points out that the communication barriers in online group interactions mentioned above tend to hinder effective collaboration (Abedi & Tabatabaee-Yazdi, 2023). Suitable interventions are required to enhance communication skills within a collaborative context.

Wong and Looi have defined seamless learning as a complete integration of formal and informal learning activities that helps overcome the problem of fragmentation across learning spaces. Looi et al. (2019) define seamless learning as a continuous flow of interconnected learning experiences aided by technology that provides access to information anytime and anywhere. This approach supports personalized and group-focused instruction which makes it invaluable for fostering digital literacy skills in the context of online collaborative environments.

Moreover, the application of gamification techniques in online education frameworks has been shown to significantly enhance learner participation and synergy. Torres-Toukoumidis and Mäeots found that gamification enhances digital competence because it increases student participation, which enhances collaboration in online environments (Torres-Toukoumidis & Maeöts, 2019). Thus, the right combination of technology, effective pedagogical frameworks, and gamification techniques can constructively facilitate the development of digital literacy skills among educators.

While some scholars have focused on the concept of digital literacy combined with collaborative learning, there is a remarkable gap in the scope of the application of seamless learning in educator training on digital literacy skills. Most of the studies identified by Männistö et al. focus on the use of e-Learning tools during higher education but largely neglect the application of seamless learning aimed at improving teachers' digital literacy skills (Männistö et al., 2019).

There is a significant gap in research on the adaptation of collaborative learning strategies to meet educators' specific needs regarding digital literacy skills training (Männistö et al., 2020; Rafi et al., 2019). However, their importance as a reason for collaborative skills requires further study to clarify how these skills can be developed through digitally mediated instruction (Anshori et al., 2023).

Scholars have suggested the use of digital technologies such as Learning Management Systems (LMS), mobile devices, and online collaborative tools such as Zoom and Google Docs to bridge this gap and improve students' digital literacy alongside their collaborative skills (Männistö et al., 2019; Soufghalem, 2024). Regular use of these platforms in classroom activities has been shown to improve students' abilities to collaborate, share ideas, and provide constructive feedback. Nevertheless, technology alone is insufficient; effective pedagogical design is required to ensure that technological affordances translate into meaningful collaborative experiences (Abedi & Tabatabaee-Yazdi, 2023). Communication barriers, particularly in online group learning, can impede successful collaboration, highlighting the need for targeted interventions to develop both digital and communicative competencies.

The present study is guided by four central research questions that collectively address the integration of collaborative, seamless, and online learning approaches in digital literacy training for educators:

RQ1. How can collaborative learning be effectively implemented in digital literacy training?

RQ2. How effective is the application of online learning in digital literacy training?

RQ3. How can digital literacy resources be optimized to support professional development for educators?

RQ4. What technologies are employed in digital literacy training using collaborative learning, seamless learning, and online learning approaches?

The objective of this systematic literature review is to explore the application of collaborative and online learning approaches in the context of digital literacy training for educators. The study also seeks to identify the technologies used in these training programs with a focus on seamless learning, and the relevant digital literacy content for educators. The study will focus on the role of seamless learning strategies to provide flexible, mobile-enabled learning opportunities, bridging the gap between formal and informal learning environments. This research examines various information and instructional resources within the scope of digital literacy training with particular emphasis on the effectiveness of these strategies in improving instructors' digital skills.

## METHOD

This investigation undertook a systematic literature review, gathering resources from ERIC and other scholarly education databases. The search strategy used two major phrase pairs as keywords: (1) "Digital Literacy" AND "Online Learning" and (2) "Seamless Learning" AND "Digital Competency." Articles obtained for this research were only those published within the last five years (2020–2024), which align with criteria set by Tsafnat et al. to ensure relevance to current educational and technological contexts (Tsafnat et al., 2014). The reviewed literature

satisfies the PRISMA guidelines as referenced by Page et al. (2021). which ensures that transparency and reproducibility are maintained throughout the systematic review process. Adopting a Double Reviewer's Systematic Literature Review paradigm enabled two researchers to conduct every single step of the literature search, screening, and analysis processes. Though this approach may ensure efficiency, it does come with the risk of bias. Invaluable insights outside published work are crucial, therefore relevant grey literature was used (Lavis et al., 2005).

The overarching themes pertaining to each study were formulated through qualitative analysis via coding based on: the use of collaborative learning in training for digital literacy (RQ1), online learning implementation towards digital literacy (RQ2), suitable content for educators concerning digital literacy scholarly resources (RQ3); as well as technologies employed in collaborative learning, seamless learning, or other online instructional paradigms (RQ4).

**Study Selection**

The process undertaken in this systematic review has a definable step regarding sample selection that ensured all relevant studies were captured. Criteria were set to focus on research performed within the framework of an educational environment with technology aimed at fostering digital literacy which included collaborative learning, seamless learning, or any form of online learning. Those studies which did not explicitly mention digital competency were excluded from consideration. In line with Li et al. (2014), all studies found at first were screened based on these criteria for alignment and uniformity in the context of relevance as highlighted by Li et al's concern with inclusion and exclusion criteria in systematic reviews.

**Procedure for Data Collection**

The data acquisition commenced with a keyword search in the ERIC database. From a total of 95 screened publications, further analysis was only conducted on those that met the inclusion criteria, yielding a final sample of 15 articles. Each study was analysed based on its particular methodology, outcomes, and contributions towards understanding students' digital literacy competencies in relation to collaborative and online learning frameworks. Data extraction and synthesis were performed through quantitative and qualitative analysis following Lichtenstein et al.'s (Lichtenstein et al., 2008) and McGowan et al. (McGowan et al., 2021) approaches which highlight synthesis as the critical step towards achieving clarity on complex topics.

**Data Analysis Techniques**

The data extracted from the selected studies were analyzed using descriptive statistical methods to identify general trends in the literature. Additionally, a meta-analysis was performed to synthesize quantitative results from several studies (Page et al., 2021). For studies using mixed-methods designs, thematic analysis was employed to uncover patterns and relationships between variables that could not be quantitatively measured, as indicated by Tsafnat et al. (Tsafnat et al., 2014). Table 1 shows data extraction results.

The temporal distribution of the analyzed studies in Figure 1 reveals a concentrated focus on digital literacy and online learning research. The dataset comprises 15 studies published between 2022 and 2024, with 6 studies (40.0%) published in 2022, 7 studies (46.7%) in 2023, and 2 studies (13.3%) in 2024. This trend suggests a peak in scholarly output in 2022–2023.

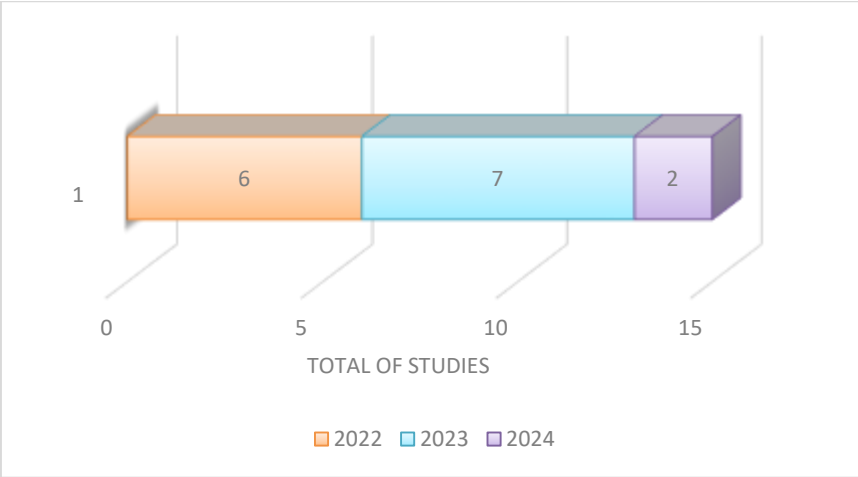


Figure 1. Frequency Distribution of Included Studies by Publication Year (2022–2024)

Figure 2 demonstrates a diverse geographical representation, encompassing research conducted across twelve countries. The distribution reveals that Thailand, Indonesia, Turkey, and the United States each contributed two studies (representing approximately 14.3% of the total studies per country), indicating these nations' active engagement in digital literacy and online learning research. The remaining eight countries—Germany, Greece, the Netherlands, Pakistan, Poland, South Africa, Spain, and the United Kingdom—each contributed one study (constituting 7.1% of the total per country). This distribution highlights a global interest in digital literacy, with notable representation from both Global North and Global South contexts.


Figure 2. Geographical Distribution of Studies by Country (N = 15)

Table 1. Data Extraction Results

| Author(s) | Methodology Used | Research Context | Sample Size | Key Findings | Research Limitations |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Goria (Goria & Konstantinidis, 2023) | Participatory pedagogy model development | Online distance learning pedagogy | Not specified (in the United Kingdom, Netherlands) | COMP-PLETE model improves community, participation, and personalized learning in online education. | Does not account for differences in access to technology across different student populations. |
| Grothaus (Grothaus, 2022) | In-depth interviews of 20 students across Germany and Thailand | Collaborative online learning across cultures in Germany and Thailand | 20 students (9 from Germany, 11 from Thailand) | Social and teaching presence vary across cultural contexts, with different challenges in collaborative online learning. | Limited to Germany and Thailand, might not apply to other cultures. |
| Dennen et al. (Dennen et al., 2023) | Survey of 350 college students | Exploring networked knowledge activities and digital competence | 350 college students (United States) | Students are more engaged in passive online activities, lacking skills in digital creation and curation. | Limited to students from one U.S. university, with limited diversity in social media use for career contexts. |
| Jamil and Kusmaladewi (Jamil & Kusmaladewi, 2022) | Qualitative research methods with descriptive percentage analysis | Evaluation of UT's SUAKA-UT online educational resources and their accessibility | 123 students in Indonesia | SUAKA-UT was found to be accessible and met students' needs for flexible learning resources. | Focused on students from a single distance learning institution in Indonesia. |
| Ahmad et al. (Ahmad et al., 2023) | Quantitative descriptive survey research method | Digital literacy competencies of distance learners in Khyber Pakhtunkhwa higher education | 95 distance learners in Pakistan | Some distance learners lacked digital literacy, but many were aware of online collaboration tools. | Limited to distance learners in one region of Pakistan. |
| Kwiatkowska and Wiśniewska-Nogaj (Kwiatkowska & Wisniewska-Nogaj, 2022) | Survey of students' digital skills and analysis based on collaborative learning tasks | Examining digital skills in relation to collaborative learning in distance education | University students at Nicolaus Copernicus University, Poland | Students with higher digital skills engage more effectively in online collaborative tasks. | Focused on one university in Poland, results may not be generalizable. |
| Mphahlele (R. S. Mphahlele et al., 2023) | Mixed-methods approach | E-readiness of first-year students in using the LMS during the COVID-19 pandemic | 2,707 first-year students, 30 academics (South Africa) | Challenges in adapting to online learning included limited internet access and time management issues. | Focused on first-year students at one university during the pandemic. |
| Molina-Torres (Molina-Torres, 2024) | Quantitative research using a survey | Teacher training in digital skills during COVID-19 | 172 students in Spain | Flipped learning improves digital literacy and promotes good teaching practices. | Limited to a specific university setting in Spain during the COVID-19 pandemic. |
| **Author(s)** | **Methodology Used** | **Research Context** | **Sample Size** | **Key Findings** | **Research Limitations** |

| | | | | | |
|---|---|---|---|---|---|
| Farsawang and Songkram (Farsawang & Songkram, 2023) | Mixed-methods approach using focus groups and surveys | Technology integration and adaptability in higher education post-COVID-19 | 510 students, 30 participants in Thailand | The pandemic highlighted the need for flexibility and adaptability in higher education, with digital literacy being crucial. | Limited to 22 universities in Thailand, focus on technology integration during the pandemic. |
| Özden (Özden, 2023) | Descriptive statistics, correlation and regression analysis | Digital literacy and critical thinking in instructional material development | 152 pre-service teachers in Turkey | Digital literacy and critical thinking are significant predictors for developing digital instructional materials. | Study focuses on pre-service teachers in Turkey, which may not generalize globally. |
| Rizal (Rizal et al., 2022) | Descriptive study using ADDIE model | Enhancing digital literacy in pre-service physics teachers | 40 pre-service physics teachers (Indonesia) | LMS3 enhances digital literacy and learning motivation among pre-service physics teachers. | Sample size limited to 40 pre-service teachers, only in Indonesia. |
| Devourou (Devourou et al., 2022) | Case study involving second grade students | Investigating mobile seamless learning in Greek primary education | 14 second-grade students (Greece) | Mobile seamless learning promotes collaboration and knowledge construction in primary education. | Small sample size of 14 students limits generalizability. |
| Bradley (Bradley, 2023) | Phenomenological study using in-depth interviews | Exploring social presence in online learning communities | 12 participants (United States) | Social presence and communication tools can enhance engagement and combat isolation in online learning. | Limited sample size of 12 participants, all from the same institution. |
| Morachat and Seechaliao (Morachat & Seechaliao, 2024) | Research and Development (R&D) methodology | Developing flipped learning models for Thai undergraduate students | 119 instructors, 397 students (Thailand) | Flipped learning significantly improves digital literacy in undergraduate students. | Study focused on a single university, results may not generalize across all contexts. |
| İnan and Kılıçer (Inan & Kiliçer, 2022) | Quasi-experimental design with pretest-posttest control group | Exploring the effect of flipped learning on pre-service teachers' information literacy and educational beliefs | 74 pre-service teachers (Turkey) | Flipped learning contributed to the improvement of information literacy skills and educational beliefs of pre-service teachers. | Limited to one university and a specific group of pre-service teachers in Turkey. |

The methodological landscape of the examined studies reveals a balanced yet varied application of research paradigms in digital literacy investigations (see Figure 3). Quantitative methodologies were employed in 4 studies (26.7%), reflecting a strong emphasis on empirical measurement and statistical analysis of digital competency development. An equal number of studies (4, 26.7%) adopted mixed-methods approaches, demonstrating the field's recognition of the need to combine numerical data with qualitative insights to capture the multifaceted nature of digital literacy. Qualitative designs were utilized in 3 studies (20.0%), providing in-depth exploration of learner experiences and pedagogical dynamics. Additionally, 2 studies (13.3%) employed case study

methodologies, offering rich contextual examinations of specific digital literacy interventions, while another 2 studies (13.3%) implemented quasi-experimental designs to establish causal relationships in technology-enhanced learning environments.

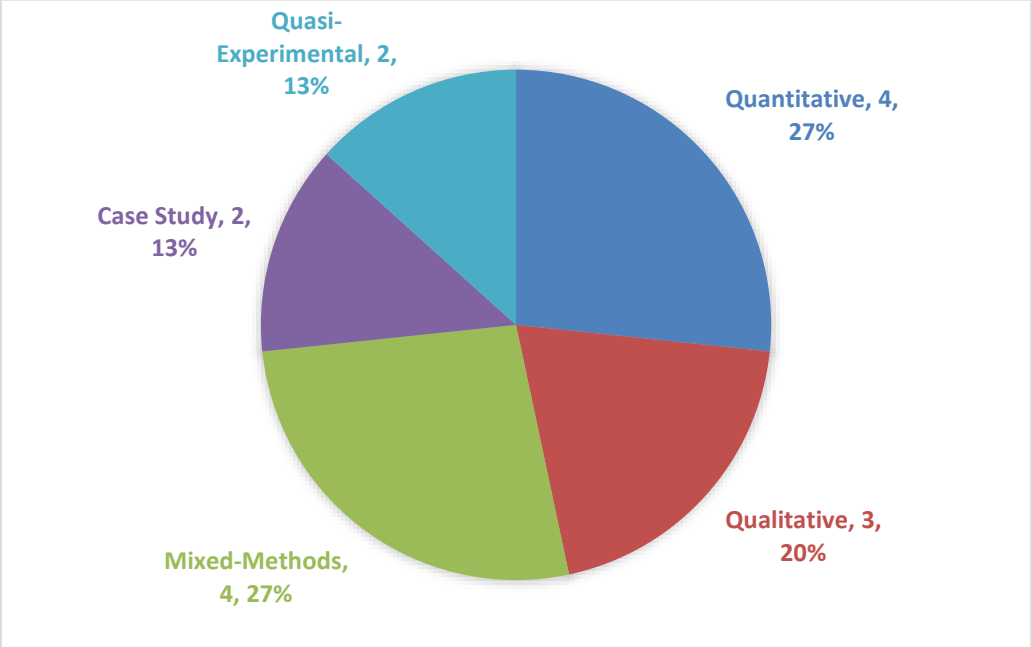


Figure 3. Methodological Approaches Employed in Digital Literacy Research

## RESULTS AND DISCUSSION

### The Implementation of Collaborative Learning in Digital Literacy Training

In the implementation of collaborative learning for digital literacy training, various collaboration models were employed, including peer-to-peer, group-based, and team-based learning. Peer-to-peer approaches were applied through flipped classroom models, where students prepare material outside the classroom and engage in group discussions during in-class sessions. Sukma et al. demonstrated that peer-teaching models in flipped classrooms were more effective than conventional methods in enhancing students' understanding of mathematical concepts (Sukma et al., 2022). McLean et al. also emphasized that meaningful interaction amongst students during class activities improved both their understanding of the material and their social skills (McLean et al., 2016). Molina-Torres also found that pre-service teachers' digital skill development through student collaboration was facilitated by flipped classrooms (Molina-Torres, 2024). Furthermore, Ruiz de Miras et al. (2021) discussed the positive impacts of a combination of peer instruction and flipped classroom teaching on attendance and learning outcomes, thus demonstrating the value of engagement in active interaction and collaboration for developing digital literacy skills.

Learning Management Systems (LMS) such as Moodle were used for collaborative teaching and learning, particularly in South Africa, where they facilitated online group work and cultivated

shared responsibility among students concerning task completion (R. S. Mphahlele et al., 2023; R. S. S. Mphahlele & Jikpamu, 2021). However, the collaborative practices observed in Mphahlele et al.'s study were limited by low student participation, insufficient digital literacy skills, and technological infrastructure challenges, which hindered full engagement in online collaborative learning (R. S. Mphahlele et al., 2023). This illustrates a need to rethink limitations within designed collaboration frameworks. An alternative focus is team-based approaches as provided by the COMP-PLETE programme which centred on remote project teamwork and enhanced active student participation through project-based learning (Goria & Konstantinidis, 2023). However, the program does not address gaps in technological access available to students from varying populations, which can undermine the impact of these collaborative activities.

Mobile technology's contribution to seamless learning has proved effective in increasing the engagement of students both within and beyond the classroom (Amhag, 2017). This type of learning utilises mobile devices such as tablets and smartphones, which enable learners to access educational resources whenever and wherever necessary. Nonetheless, the study pointed out some difficulties concerning access to technology and the requirement for careful planning of lessons. As proposed by Hwang et al. (2015), seamless learning provides opportunities for continuous collaboration that mobile technology can greatly enhance.

Dennen et al. discovereed that the digital skills students gain from social media platforms for mundane chores do not translate into meaningful capabilities in academic settings (Dennen et al., 2023; Morachat & Seechaliao, 2024). This reinforces the argument that students' digital competencies gaps—especially their academic use of technology—stand to improve with integration of online collaboration tools offered by flipped classroom and seamless learning models.

This earlier research has already been noted in the literature with respect to collaborative forms of instruction such as peer-to-peer, group, and team learning supporting the development of digital literacy skills. İnan and Kılıçer pointed out that mobile-assisted flipped classrooms fostered stronger information literacy and collaboration among pre-service teachers (Inan & Kiliçer, 2022). Additionally, Sukma et al. (2022) and McLean et al. (2016) confirmed that flipped classrooms not only enhance content comprehension but also facilitate collaborative learning through direct student interactions.

The results align with Molina-Torres' (Molina-Torres, 2024) findings, where flipped classrooms fostered collaborative interaction in the classroom. Furthermore, the use of LMS platforms, such as Moodle, aligns with studies in South Africa, which highlight the role of LMS in facilitating effective collaborative learning (Kwiatkowska & Wisniewska-Nogaj, 2022). In the same vein, the team-based learning model employed by COMP-PLETE is akin to other collaborative distance

learning frameworks that facilitate enhanced active participation of students in team-based work. (Devourou et al., 2022).

Seamless learning also adds a new dimension to collaborative learning. Hwang et al. proposed the seamless flipped learning model, which combines mobile and wireless technologies to enable continuous learning across contexts, such as home, classrooms, and outdoor settings (Hwang et al., 2015). This supports findings by Devourou et al. that mobile devices facilitate collaboration both inside and outside the classroom (Devourou et al., 2022). These approaches not only support collaboration but also strengthen digital literacy for both students and educators in modern learning environments. However, the dependency on adequate technological access and the challenges educators face in designing complex collaborative learning activities remain limitations of seamless learning.

The implementation of collaborative learning models in digital literacy training has had a significant impact on the development of collaborative and digital skills among educators. The use of flipped classrooms and LMS platforms not only increased student engagement in the learning process but also helped develop critical and collaborative thinking skills. From a practical perspective, tools like Google Docs and social media have enabled more effective cross-cultural collaboration, although cultural differences persist. In the future, using technology and gamification in cooperative models will help enhance the level of student participation while improving digital literacy skills.

These findings have important scientific and practical implications. The controversies surrounding the application of technology in education centre around themes such as peer instruction, flipped classrooms, and seamless learning to a much larger extent than is found in the existing literature on collaborative learning because they demonstrate how technology can make collaborative learning more efficient (McLean et al., 2016; Sukma et al., 2022). Moreover, Hwang et al. (2015) showed that their proposed seamless flipped learning model offers a way to increase both flexibility and active student participation during the educational process.

This study underscores the need to develop specific curricula and strategies tailored to foster digital literacy competency among teachers. With the proper implementation of flipped classrooms along with the peer instructional model, student engagement becomes revitalised thanks to seamless learning technologies which provide learning opportunities anytime from any location. The demonstrative integration of team-based instructional approaches like COMP-PLETE shows that engaged collaboration turns out to be intensive in digital education overall.

**The Application of Online Learning in Digital Literacy Training**

The implementation of online learning in digital literacy training largely depends on the use of platforms such as LMS and Google Classroom. These platforms facilitate flexible access to learning materials, assignments, and evaluations, allowing students to learn at their own pace

and from any location. As noted by Rizal et al. (2022), utilizing LMS through smartphones enhanced the digital literacy of pre-service physics teachers, as it eliminated restrictions on accessing learning materials. Furthermore, Moodle and Google Classroom facilitate e-collaborations such as discussion boards, electronic assignments, and virtual group work. In South Africa, LMS were especially important during the COVID-19 pandemic in enabling group work as well as online discussions (R. S. Mphahlele et al., 2023). Despite the widespread use of LMS platforms, some students, particularly those from rural areas, face challenges in accessing and using these platforms due to limited digital literacy skills. Thus, it is crucial to actively involve students in LMS activities to enhance their digital competency.

The significance of seamless learning facilitated by mobile technologies in online educational settings. Students can engage in ongoing learning across several contexts through the utilization of laptops and tablets (Amhag et al., 2019). This corresponds with the findings of Rizal et al. (2022), which highlighted that LMS systems enable learning beyond time and place. Dennen et al. (2023) emphasized that actively participating in social media does little to equip students with skills relevant for the classroom, because most of what they will learn will be irrelevant. Consequently, more organised and purposeful forms of education available from within a learner's environment become possible through LMS platforms.

These findings align with the literature that focuses on the role of LMS and other online learning resources in equipping learners with relevant digital skills. Hamid et al. (2019) reported that Google Classroom was applied within mobile seamless learning environments to support informal alongside formal instructional activities, providing a range of flexible learning alternatives. Kwiatkowska and Wiśniewska-Nogaj further confirmed this by reporting that discussion forums, document sharing, and group work used in LMS platform classes promoted collaborative learning online (Kwiatkowska & Wisniewska-Nogaj, 2022). Furthermore, Google Drive facilitates synchronous collaboration, allowing students to work together in real-time (Bradley, 2023). The variety of studies conducted where participants were provided with LMS platforms indicates these tools not only strengthen learners' digital literacy but also their collaborative competencies within the framework of online education.

Grothaus cited cultural issues as a significant aspect in the implementation of online platforms for cross-cultural education (Grothaus, 2022). Cooperation through the Google Classroom or an LMS may be limited because readiness for technology acceptance among students from culturally diverse contexts is low due to strong local cultural norms. The conclusions drawn from the lessons learned about the web-based applications support formerly expressed views on the importance of enhancing students' skills in collaboration and scaffolding with technology on learning management systems (LMS) and Google Classroom. Practically speaking, these applications make it possible for learners to organise materials as well as collaborate or work in groups during

assignments or in projects. As pointed out by Kwiatkowska & Wisniewska-Nogaj (2022) and Rizal et al. (2022), participation, both asynchronous and synchronous, in discussions held online via LMS platforms contribute towards improvement of one's critical thinking and digital skills. In time, the continued application of mobile devices together with online collaboration software will remove obstacles to education toward increasing opportunities for instructional access within training on digital literacy teaching.

**Digital Literacy Resources for Educators**

The curriculum for digital literacy training for teachers has specific objectives, which include improving skills relevant to the use of technology, establishing organizational efficiency, and simplifying processes. These competencies include the use of almost all educational software, from elementary and secondary levels, to managing digital content and implementing learning management systems (Rizal et al., 2022). This training prioritizes the cultivation of critical thinking and proficiency in digital tools essential for creating creative educational materials (Özden, 2023). Ahmad et al. underscore that digital literacy encompasses digital security, which involves comprehension of copyright, data protection, and privacy—factors that are more vital in contemporary online learning contexts (Ahmad et al., 2023).

In line with Dennen et al., digital literacy goes beyond technical skills and involves the careful use of digital collaboration tools within formal educational contexts (Dennen et al., 2023). This helps bridge the gap between educators' personal digital skills and their professional application in teaching. However, previous research shows that empirical analysis regarding the specific training needs of educators, particularly in higher education for teaching and research, remains limited. The content of digital literacy often differs from digital competency content in broader educational contexts (Inamorato dos Santos et al., 2023). Thus, further research on digital competency content is urgently needed.

These findings align with previous literature, which emphasizes the relevance and importance of digital literacy in education. Jamil and Kusmaladewi argue that social media literacy is an integral part of digital literacy training, where educators are taught to use social media platforms ethically when interacting with students (Jamil & Kusmaladewi, 2022). This is important for modern teachers, who must navigate the use of digital collaboration tools such as Zoom and Google Docs. In the case of borderless learning, Amhag claims that the scope of digital literacy should also include mobile learning competencies that enable omnipresent learning (Amhag, 2017; Amhag et al., 2019).

Farsawang and Songkram emphasize that post-pandemic digital literacy curriculum has increasingly concentrated on technological adaptation, essential for educators to effectively utilize LMS and collaborative tools in both synchronous and asynchronous learning environments

(Farsawang & Songkram, 2023). These training materials have successfully demonstrated their benefits in improving classroom teaching skills, fostering efficient online classroom management. According to Grothaus, sociocultural aspects shape the implementation of digital literacy content for educators (Grothaus, 2022). This study illustrates that the methods used to teach digital literacy need to be adapted to suit the culture and society in which educators operate, as cultural variations have implications for the adoption and impact of technology in teaching. This study emphasizes, from a scientific perspective, how a well-designed comprehensive course on digital pedagogy can develop educators who are prepared to face the challenges posed by the realities of digital instruction. From a practical perspective, training that focuses on the use of instructional technology tools, cyber safety, and social media education allows for efficient integration of technology into classroom instruction. As Rizal et al. note, this training not only helps educators master basic skills but also enables them to develop advanced competencies, such as designing innovative and relevant digital teaching materials (Rizal et al., 2022). As reliance on technology in education grows, structured and relevant content becomes increasingly important to ensure that educators can effectively support digital learning for their students.

**Technologies Employed in Digital Literacy Training with Collaborative Learning, Seamless Learning, and Online Learning Approaches**

Digital literacy training that integrates collaborative learning, seamless learning, and online learning methodologies use numerous technologies to facilitate the educational process. The principal technologies utilized are LMS such as Moodle, Blackboard, Canvas, and Google Classroom, which enable the administration of learning content, online discussion forums, assignments, and assessments (Özden, 2023; Rizal et al., 2022). Furthermore, collaborative tools such as Google Docs, Zoom, Microsoft Teams, and WhatsApp are used to support group work and both synchronous and asynchronous discussions among participants (Bradley, 2023; Jamil & Kusmaladewi, 2022). In the context of seamless learning, mobile devices in the Bring Your Own Device (BYOD) model allow participants to continue learning anytime and anywhere, without location constraints (Farsawang & Songkram, 2023). Studies by Cornide-Reyes et al. (2020) and Pornpongtechavanich & Wannapiroon (2021) focused on the need for learning platforms that support real-time verbal communication and collaborative ecosystems driven by interactions in a seamless learning environment. Therefore, there is a movement towards a more active and collaborative instructional environment.

Mobile devices facilitate seamless learning by enabling participants to switch effortlessly between various learning environments (Amhag, 2017). This concept enables devices like smartphones and tablets to offer unrestricted access to resources, enhancing collaborative and ongoing learning beyond the classroom. The significance of technology in comprehensive digital literacy, highlighting the disparity between the technical competencies students acquire in personal

settings and their utilization in educational situations (Dennen et al., 2023). LMS platforms facilitate collaboration among students within structured educational settings by providing essential tools.

These findings are consistent with literature that highlights the crucial role of LMS and collaborative tools in digital learning. Studies by Hamid et al. (Hamid et al., 2019) and Kwiatkowska & Wiśniewska-Nogaj (Kwiatkowska & Wisniewska-Nogaj, 2022) emphasize that LMS platforms such as Moodle and Google Classroom facilitate collaborative learning through discussion forums, document sharing, and group assignments. Collaborative tools like Google Docs have also been widely used in team-based projects to support real-time interactions among participants Pornpongtechavanich & Wannapiroon (2021).

This aligns with Bradley's (2023) research, which shows effectiveness of these tools in remote group conversations. Moreover, the use of mobile phones in the BYOD paradigm as discussed in Farsawang & Songkram (2023) study supports seamless learning by enabling learners to work outside temporal and spatial boundaries, thus enhancing digital literacy.

The use of enabling technologies such as LMS, collaboration software, and mobile applications within the context of training in digital literacy offers promise toward enhanced flexibility and collaboration in the learning paradigm. It has been noted that one requirement is understanding a culture’s contextual frame when using technology to ensure its effectiveness within socioculturally diverse places (Grothaus, 2022; Surjono et al., 2019). These technologies increase learners' engagement in synchronous and asynchronous learning, promote remote collaboration, and offer unrestricted access to educational resources.

Utilizing tools such as Google Docs and Zoom fosters interactive learning environments, essential for distance and collaborative education (Özden, 2023; Rizal et al., 2022). Moreover, seamless learning technologies that employ mobile devices enable learners to engage in education at any time and place, which is particularly pertinent in contemporary educational settings (Farsawang & Songkram, 2023). Regardless of persistent problems such as the inequitable distribution of devices and internet access, technology-centric interventions have significantly enhanced the prospects for improving instructors’ digital literacy.

## LIMITATIONS

This study has several limitations that should be acknowledged. First, published literature prior to 2020 or outside the scope of ERIC and selected academic databases will have been systematically excluded from consideration, thereby narrowing the literature review's timeframe to five years (2020-2024). Such constraints stand to significantly undermine the completeness of the findings. Furthermore, SLRs conducted under a Double Reviewer’s Systematic Literature Review approach lack rigor due to reliance on two individuals for all components of literature

search, screening, and analysis. This increases the potential for bias in the selection and interpretation of the literature, which could affect the validity of the findings.

The examination is limited to only 15 papers, which unlikely provides an overarching view on the application of collaborative and seamless learning in relation to digital literacy. This study largely concentrates on the integration of technology in higher education, but its application in elementary and secondary education is inadequately covered. The absence of empirical evidence demonstrating the direct effect of digital literacy training grounded in collaborative and seamless learning is a challenge. Numerous recent studies seem to be focused on concepts or participants' experiences and it is clear that further investigation employing more sophisticated experimental frameworks is needed to deepen understanding of the impact and lasting effects these methodologies have on educators' digital competencies.

## CONCLUSION

This research investigated the use of information technology with respect to digital literacy training for teachers under the overlap of collaborative, seamless, and online learning. The results indicate that Learning Management Systems, collaborative tools, as well as mobile devices in BYOD models promote engagement and collaboration. They facilitate real-time and delayed interaction, thus strengthening teachers' engagement digitally skilled teaching competencies.

Even though seamless learning facilitates persistent collaboration, it is not completely embedded within integration of all elements of the instructional design. This underscores the perennial problem of lack of focused attempts to ensure collaboration permeates every stage of the learning cycle. In addition, gaps in possession of internet connected devices still poses an enormous challenge with regard to these methods being successfully adopted.

Future research should expand to include a wider range of educational settings and explore contextual factors influencing the adoption of digital literacy training models. It is also essential to further investigate the integration of collaborative learning and seamless learning, given the current lack of studies exploring their combined impact on digital literacy development. Future studies should focus on how these approaches can be applied more effectively and comprehensively in diverse educational environments. As educational technology continues to evolve, training programs must adapt to meet the changing needs of educators, ensuring that digital literacy is cultivated in a collaborative and inclusive manner.

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