Exploring Teachers' Digital Literacy Experiences

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Abstract

The present study analysed digital literacy issues encountered by elementary school teachers in remote classrooms due to COVID-19. The study sought to derive a plan for cultivating teachers' digital literacy to support students' distance education. To this end, focus group interviews were conducted with five elementary school teachers in charge of upper grades, the results were analysed, and strategies to improve teacher digital literacy were derived. Specifically, three main areas of teacher digital literacy were identified for improvement. The first was providing training to use digital devices and online platforms, develop online content, and strengthen copyright understanding. The second was providing professional development programs to train digital teaching methods or pedagogies by level and by subject characteristics. The third was activating online and offline platforms for information sharing among teachers and establish a digital teaching support system. This study will be of value to teachers and school administrations in preparing for distance education in the era of digital transformation because it presents measures to foster teachers' digital literacy required by future society.

Keywords: teachers' digital literacy, digital competency, elementary school, distance learning

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The digital transformation brought about by the COVID-19 pandemic has also profoundly affected the education sector, creating demand for various educational innovations to adapt to the new educational landscape. The field of education has been changed by untact digital trends, and interest in various forms of educational technology has increased, such as artificial intelligence, augmented reality, and virtual reality. There is new demand for educational innovation to nurture learners in the era of digital transformation. In future societies where digital technology will continue to develop, learners who are able to integrate creativity, personality, and emotion will thrive in comparison to learners who merely possess various knowledge (Trilling & Fadel, 2009). Therefore, for successful distance learning, it is necessary to provided learner-centred collaborative learning opportunities to support the development of creativity, interaction, and coordination competency (Pearcy, 2014).

Despite the demand for various educational innovations within the field of education based on remote and digital paradigms, prompted by the changes induced by the COVID-19 pandemic, it has not been easy for educators to keep up with the rapidly changing trends in the field of education. The expansion of distance learning due to COVID-19 has brought about many changes to the educational field, but distance learning that was conducted in response to the emergency conditions of the pandemic brought numerous problems to light, such as lack of infrastructure (Kruszewska et al., 2022), difficulty in using digital devices (Jung et al., 2020; Shagiakhmetova et al., 2022), limitations in using teaching methods (Shagiakhmetova et al., 2022), and challenges in equitable evaluation (Jung et al., 2020). In particular, elementary school students experienced more challenges in adapting to distance learning compared to middle or high school students, so elementary school educators were required to demonstrate greater capacities in designing, implementing, and assessing distance learning (Ben-Amram & Davidovitch, 2021; Taimur et al., 2021; van Wyk, 2021; Wang et al., 2021).

The direction of education has also been changing to support learner-centred, individualized, and customized education based on digital technology. Against this backdrop, changes were also required in teacher professionalism in order to meet the demands of future education. In particular, teachers' digital literacy has been critical to preparing distance instruction (Prior et al., 2016). In this context, exploring challenges encountered by educators in terms of digital literacy during distance learning, and deriving insights for cultivating teacher digital literacy, can contribute to enhancing distance learning quality.

Therefore, the present study aimed to analyse the status of teachers' digital literacy as a prerequisite for the effective implementation of distance teaching, which has become an essential modality in the realm of school education, particularly in the context of the second year of the COVID-19 pandemic. In particular, this study focused on exploring the difficulties of elementary school teachers in providing distance learning to elementary school students due to COVID-19 in connection with teacher digital literacy. Through a review of the literature and semi-structured interviews with elementary school teachers, the present study sought to identify the components of teacher digital literacy that required support and suggest implications for teacher digital literacy cultivation. In other words, the research concentrated on the use of teachers' digital literacy for the purpose of supporting students within distance instructional contexts. To achieve this, the study was guided by two research questions. What digital literacy challenges did elementary school teachers face? How can schools foster digital literacy among elementary school teachers?

Literature Review

Components of Teacher Digital Literacy

Digital literacy refers to "the overall capacity of an individual to use digital media, information processing and retrieval, participate in social networks for the purpose of creating and sharing knowledge, and employ a wide range of computing skills" (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2011, p. 1). With the advent of the digital transformation era, there has been a growing interest in digital literacy. Digital literacy, encompassing the ability to explore and use information using digital technologies, has also been referred to as digital competence (Jung & Shin, 2022). In this study, the concept of digital literacy is approached comprehensively to encompass digital competence, information and communication technology (ICT) skills, and related aspects.

Recently, within the educational domain, there has been a growing emphasis on digital literacy as a critical competency for teachers, given the advancement of Internet technologies and the expansion of distance education (From, 2017). With the full-scale implementation of distance education during the first half of 2020 due to the COVID-19 pandemic, the importance of teachers' digital literacy has escalated in formulating effective teaching and learning strategies within the distance education environment. According to prior research, teachers' digital literacy encompassed understanding and use of technology, information and data exploration and management, digital ethics and safety, active engagement, digital problem-solving, and digital teaching and learning strategies (Jung & Shin, 2022). Additionally, other essential components of teachers' digital literacy, as identified by prominent global institutions, encompassed digital content creation and problem solving (El Instituto Nacional de Tecnologías Educativas y Formación del Profesorado [INTEF], 2020), educational sciences and ICT (UNESCO, 2011), and activity and learning environment design (International Society for Technology in Education [ISTE], 2017). ISTE, INTEF, and UNESCO have all conducted extensive research on digital competence over the years, providing valuable resources referenced by many scholars.

Table 1

Digital Competence Elements Identified by Major Institutions

Organization and citation	Elements of digital competence
INTEF (2020)	Information literacy, problem solving, safety, digital content creation, communication and collaboration
UNESCO (2011)	Understanding ICT in education, curriculum and assessment, pedagogy, ICT, organization and administration
ISTE (2017)	Collaborators: Collaboration with both colleagues and students to improve practice, learner-driven activities and environments
	Facilitators: Facilitating learning with technology to support student achievement

As observed thus far, the digital literacy that teachers need to prepare and deliver digital instruction has been composed of skills involving the use of digital devices and technology, information collection and analysis, the creation of video content, and the application of teaching and learning methods for distance instruction (Redecker & Punie, 2017). Moreover, teachers' digital literacy encompassed problem solving, communication and collaboration, as well as organizational and managerial skills (Redecker & Punie, 2017; UNESCO, 2018). Therefore, teacher digital literacy has been defined as the ability not only to effectively use digital devices and online platforms, but also the capability to implement a variety of teaching and learning strategies effectively in actual lessons, leading to successful distance learning.

Thus, cultivating post-pandemic teacher digital literacy has entailed providing opportunities to enhance not only the digital device-related competencies outlined earlier but also skills in teaching and learning strategies, communication, operation, and management that are crucial for effectively guiding distance instruction. In this regard, the present study divided teachers' digital literacy into the following six areas and conducted research based on them: (a) understanding and use of technology, (b) search for and administration of information and data, (c) digital ethics and safety, (d) proactive participation, (e) digital problem-solving, and f) digital learning and teaching strategies.

Challenges in Distance Education and Teacher Digital Literacy

In attempting to cultivate post-pandemic digital literacy among elementary school teachers, it is useful to examine the challenges they faced when preparing their courses for online instruction during the pandemic. A review of the literature on this topic has suggested that teachers had difficulties with using digital technologies, with information retrieval when creating or adapting course materials, and with communicating with students.

Pandemic-induced school closures in early 2020 necessitated the use of a variety of technological devices for effective remote teaching, and research has suggested that elementary teachers who possessed prior knowledge and experience with information and communication technologies fared better in adapting their courses to online instruction (Bozkurt et al., 2020; Woltran et al., 2021). However, even younger teachers who were considered digital natives (Prensky, 2001) often did not possess extensive knowledge of digital technologies (König et al., 2020; Kundu & Bej, 2021). This is in line with a body of research showing that very few teachers were knowledgeable about digital education prior to the pandemic (Wu, 2021). This lack of knowledge and experience with regard to digital technologies caused disruptions to the effective delivery of online instruction for a number of elementary educators (Klapproth et al., 2020). Consequently, elementary teachers required training in the use of digital technologies and related teaching methods to ensure the smooth delivery of online instruction (Kundu & Bej, 2021).

The shift to online modes of instruction have often necessitated the creation of new learning materials that students could access online. While the Internet offered an abundance of educational resources for young learners (Hew & Cheung, 2020), elementary instructors often struggled with information retrieval in their

quest to identify pertinent, accurate, and age-appropriate resources. This was because discerning the credibility and authenticity of online sources required high levels of digital and media literacy, and many elementary teachers lack training in these skills (Scull & Kupersmidt, 2011). To address this, Wen and Shih (2008) recommended the incorporation of information literacy training in teacher education programs.

Effective communication is crucial in any educational setting, but particularly so with distance education for elementary students. Elementary school teachers encountered a number of challenges in maintaining clear and engaging communication with their young students through digital platforms. This lack of communication between teachers and students seemed to have negatively impacted students' emotional well-being, as research has shown that elementary students were more likely to report missing their teachers during distance learning as compared to middle and high school students (Holtgrewe et al., 2020). The feeling was mutual, as many teachers reported feelings of missing their students due to the lack of in-person contact during the pandemic (Letzel et al., 2020). Such disruptions to the communications and relationships between teachers and students were cited as a major source of stress for elementary teachers during the pandemic (Anderson et al., 2021). Due to school closures, elementary school teachers often relied on parents for communication with students, which resulted in significant challenges (Ferguson et al., 2021; Kundu & Bej, 2021). This indirect communication method exacerbated teachers' difficulties in trying to maintain open communication and good relationships with large numbers of students (Kim & Asbury, 2020). Therefore, it is fair to say that the closure of schools disrupted or at least weakened the communicative bonds between students and teachers, which were typically a significant source of satisfaction for educators (Colao et al., 2020) and students.

Summary

Extant research has suggested that teachers realize the need to be able to use digital devices, retrieve information, and communicate with students in order to smoothly deliver distance education. For this reason, cultivating teacher digital literacy is important. In order to resolve the difficulties teachers have experienced, technology-related support for the development of digital literacy is needed. Moreover, there has been a need to provide support for teaching and learning method development (UNESCO, 2011) and problem-solving capabilities using digital devices (INTEF, 2020) in order to foster learners' problem-solving skills required in future societies.

Method

Research Procedure

This study consisted of a literature review and a focus group interview to identify the challenges and digital literacy status of teachers in distance learning situations, and to assess and analyse the digital literacy of elementary school teachers in the era of digital transformation. Table 2 outlines the specific research procedure for this study.

Table 2

Research Procedure

Step	Description	Method
1. Review literature and prepare research	Set the research topic and establish the research plan Analyse the digital literacy literature	Literature review
2. Develop interview questionnaire	Develop a semi-structured interview questionnaire	Expert review
3. conduct focus group interviews	Conduct interviews with teachers	In-depth interviews
4. Analyse status and issues	Analyse digital literacy status and issues	Analysis of interviews
5. Deduce implications	Draw implications for improving teacher digital literacy through expert review	Cross-analysis by researchers

In the preliminary phase of the study, the characteristics of teacher digital literacy were explored through analyses of the literature related to distance learning and digital literacy. Second, an interview questionnaire was developed based on the implications of literature reviews. The questionnaire was revised and refined for validity after three rounds of review by five PhD-holders in education, each of whom had more than 10 years of teaching or research experience. Third, focus group interviews were conducted using the developed interview questionnaire. Fourth, the current status and issues related to the digital literacy of elementary school teachers were analysed. Fifth, based on the findings of the literature reviews and the focus group interviews, implications for promoting teacher digital literacy were deduced.

Focus Group Interviews and Analysis

The focus group interviews, which were the core research method of this study, were conducted with five teachers in charge of upper grades in elementary schools. The interviewees were selected by the recommendation of the city and provincial education department officials in charge of distance learning and related tasks. Information on the participants' teaching experience is shown in Table 3.

Table 3

Participants' Teaching Experience

Participant identifier	Teaching experience	Grade taught
A	10 years	4th grade
B	10 years	5th grade
C	11 years	6th grade
D	12 years	6th grade
E	13 years	6th grade

Each interview was conducted via video teleconferencing and took between 60 and 90 minutes. Participant responses were recorded and transcribed with the consent of all participants prior to the interview. The content of the interviews consisted of experiences and challenges related to distance learning, and the status

and issues of teacher digital literacy based on the literature review (see Table 4). The interviews were conducted based on a semi-structured questionnaire, and additional questions were asked, if necessary, without deviating significantly from the research purpose. After transcribing the recordings, each researcher read all the transcripts to identify key concepts and designate themes for each category. Then, the content that fit into the themes of each category were classified, and where disagreements occurred, a consensus was reached among the researchers through cross-analysis.

Table 4

Key Interview Questions

Area	Key question
Understanding and use of technology	What challenges have you experienced with using digital devices and online platforms, and creating digital content?
Search for and administration of information and data	What challenges have you experienced with searching for, understanding, and reconstructing information and data?
Digital ethics and safety	What challenges have you experienced with digital manners, protection of private information, and protection of copyright?
Proactive participation	What challenges have you experienced with communication and collaboration via digital devices?
Digital problem-solving	What challenges have you experienced while helping students solve digital problem using critical thinking?
Digital learning and teaching strategies	What challenges have you experienced with designing and developing distance learning?

Analysis Results of Elementary School Teacher Interview

Understanding and Using Technology

According to the interviewees, students acquired the necessary skills to use digital technology relatively quickly. However, in the lower grades (i.e., grades 1 to 3), students struggled to use various functions and settings of digital technology and teachers afforded substantial support related to these. Prior to COVID-19, teachers used digital devices in their classes based on their own interests, and there was some variation in the use of technology among teachers. Particularly during the pandemic, more experienced teachers (with at least 11 years of experience) had greater difficulty using digital devices and perceived the need for training in the use of various educational applications and programs. In particular, they felt the need for technical skills related to creating learning content and requested more systematic training to promote their content-authoring competency. Some of the interviewees benefited from training on online platforms.

Accordingly, the present analysis revealed that training regarding technology needed to particularly consider more experienced teachers who may have difficulty using digital devices.

> If I don't have an interest in digital devices, I'm not good at using them either. So I'd like to have more chances to strengthen my skills. Especially among more experienced colleagues, there are many teachers who are struggling, so I thought there should be some help. (Teacher C)

> It was not easy to produce learning content or use online platforms. I am learning through online lectures, but I think I need to increase my learning through various trainings because there many things that I haven't done before. (Teacher E)

Search for and Administration of Information and Data

Experienced teachers were found to have difficulties in exploring and managing information and data. In particular, they were found to be unfamiliar with gathering the necessary information and integrating it to make suitable learning materials, and the help of colleagues was found to have a significant impact in overcoming these difficulties. On the other hand, it was identified that teachers experienced difficulties in ensuring that the information they found on their own was, in fact, a useful resource. In other words, teachers needed to improve their media literacy in order to find appropriate information and modify them for educational purposes. One example of fostering teachers' media literacy was to activate teacher communities, thereby promoting voluntary collaboration among fellow colleagues. Furthermore, it was possible to offer teachers opportunities to enhance media literacy by implementing a media literacy course in teacher professional development programs.

> I am not used to creating and managing learning materials using digital devices. So it took so much time, and there were numerous errors. Fortunately, I was able to overcome these difficulties because my capable colleague helped me. (Teacher C)

> I experienced difficulties in making sure that the materials I found were appropriate. Recently, there has been a lot of fake news and inaccurate information, so it was difficult to find the exact materials I needed to make learning materials. I refined and elaborated the information through feedback from my colleagues. (Teacher E)

Digital Ethics and Safety

Regarding digital ethics and safety, teachers reported having the most difficulty with copyright protection when creating content rather than the difficulties related to personal information protection. Although there were guidelines and instructions on copyright, it was difficult for teachers to understand them all, which created difficulties for teachers in creating learning content. In addition, most of the copyright guidelines provided to teachers were not very helpful in creating learning materials in practice. Interviewees recognized the need to provide more specific guidelines.

> I really struggled with copyright when I was creating content, and even though there was a guideline, it wasn't really made up in a way that would help me produce content. (Teacher B)

I mean, there are always guidelines and instructions about copyright, but I don't think it makes sense for a teacher to teach a class with all those guidelines. (Teacher C)

Proactive Participation

Teachers found it difficult to communicate with students while teaching remotely and constantly checking in with students to see if they were learning, which affected their relationships with students. Impeded communication was identified as a challenge for teachers in managing students' learning, as students found it difficult to focus on the lesson and lost interest due to the lack of physical presence in the virtual classroom. This suggested that it was necessary to apply various tools or interactive teaching strategies to facilitate interaction with learners. Specifically, the teachers reported that they experienced communication difficulties with their students in discussion activities in the Zoom chat box, and they tried to compensate for these by changing the communication style such as using a Google Classroom online discussion forum to create anchored comments.

> Some students in the course participate, but there are some aspects where students don't communicate as efficiently as they did when they were when they were talking in a face-to-face class. . . . I think it was an opportunity for both the teacher and learners to learn a little bit about communication modalities because some of the students said that it would be much better to have a discussion using anchored comments via online discussion forum rather than chatting. (Teacher C)

On the other hand, some teachers had difficulties communicating with parents through online means and other digital devices. These difficulties were mainly due to the problem of parents themselves having difficulty communicating with others through digital technologies, as well as the fact that parents were not enthusiastic about communicating with teachers due to their own work. Moreover, the teachers also felt difficulties communicating with students in distance classes compared to face-to-face classes. Teachers experienced difficulties in delivering their messages clearly to the students and as a result, teachers used multiple channels such as text messages, e-mail, and chat apps to facilitate communication with students.

> In the end, multiple communication channels should be open so that students and parents can choose the ones that they feel comfortable communicating through, particularly with regard to the parents. (Teacher A)

On the other hand, it was found that teachers benefited from collaboration among their colleagues in distance learning situations. In particular, they obtained necessary learning materials through collaboration with teachers in charge of the same grade while producing learning content. Substantial collaborative efforts were made by teachers through active participation within the teaching and learning community, such as coaching activities on class content led by teachers with high digital literacy.

> I was very lucky that the collaboration among the teachers in the same grade was quite good. We didn't use external content, but the teachers in charge of the subject made it themselves. So, we shared it with each other. (Teacher C)

I was a teacher with above-average digital literacy in my grade. So all of the classes joined with me remotely, and I taught them. Then, I also coached the other teachers. (Teacher D)

Digital Problem-Solving

Despite the fact that teachers perceived that digital literacy helped students solve problems, there were limitations in developing students' digital problem-solving skills in online learning contexts. In the present study, digital problem-solving encompassed the concepts of critical thinking, creative thinking, logical thinking, and computational thinking. The teachers recognized that in order to support students' development of digital problem-solving skills in the era of digital transformation, where the use of digital devices is becoming more common in daily life, teachers should be provided with opportunities to develop digital problem-solving skills of their own.

Digital literacy is very relevant to developing problem solving and critical thinking skills in students, and as a competency itself, it really helps students develop higher-level skills. (Teacher D)

In terms of whether or not students are developing digital literacy or problem-solving skills, I don't think so. I think that in order for students to develop digital problem-solving, teachers' digital problem-solving plays an important role, and I don't think there are many opportunities for teachers to develop digital problem-solving. So I think there needs to be more opportunities for that. (Teacher E)

Digital Learning and Teaching Strategies

Teachers attempted to effectively design, develop, and implement their distance learning classes, but they experienced difficulties in enhancing students' sense of learning presence and in promoting learning motivation. Teachers promoted learners' participation by asking questions and applying peer assessment in group activities.

I think that's where we have to get some feedback from the students in the form of questions and answers. . . . We have to make them aware that there's a group, even in a distance learning situation. . . . I think they're more engaged when they feel like they're being evaluated by their peers. (Teacher B)

On the other hand, when designing distance learning, teachers recognized that it was necessary to use more teaching strategies that promote interaction, such as exchanging opinions and discussion activities. In addition, they acknowledged that the quality of distance learning depended largely on the competence of individual teachers, and they made great efforts to participate in relevant education programs or to learn various teaching strategies related to distance learning.

I think that teaching students how to express themselves through chat and social media is quite meaningful in terms of learning how to communicate in this era. (Teacher E)

Of course, there are some things that I just found by myself, but . . . I think I was able to learn a great deal through education programs, information, and materials that other teachers provided. (Teacher E)

Teachers recognized the need to apply the most appropriate instructional methods based on the characteristics of each grade level. For example, they said that the effectiveness of content-oriented classes and synchronous classes may vary depending on the grade, and they recognized that the most effective teaching method should be determined by considering the developmental process of each grade. In particular, it was difficult to conduct synchronous classes for lower grades because their concentration and cognitive skills were lower than those of upper grades. Teachers responded that effective teaching methods may vary not only by grade level but also by subject matter. In other words, they recognized that some domains are better taught through real-time interactivity while others are better taught through content-oriented instruction, and they used the most appropriate method for the subject matter. This result suggested that it was necessary to vary teaching methods that considered not only learner characteristics but also domain characteristics.

I think the teaching method should be differentiated according to the grade level. For example, first and third graders have very different developmental levels, so the teaching method should be designated considering the grade level. (Teacher A)

Depending on the subject and the content characteristics, some classes are more efficient with real-time delivery, and other classes are better with asynchronous delivery. (Teacher D)

Discussion

Digital Literacy Challenges Faced by Elementary School Teachers

The purpose of this study was to analyse the experiences of elementary school teachers regarding digital literacy in the context of distance learning, and to derive insights for fostering teacher digital literacy to support students' digital literacy. The implications derived from the research results were as follows.

First, the concepts of understanding and using technology, the basis of digital literacy, have been emphasized in in the literature even before the COVID-19 pandemic. However, elementary school teachers still experienced difficulties in their understanding and use of technology. Specifically, elementary school teachers faced minimal challenges in basic digital device use but had more serious difficulties in using online learning platforms and creating learning content. This implied that elementary school teachers had the basic skills to use technology but did not have sufficient capacity to apply technology to enhance distance learning. Meanwhile, elementary school teachers also experienced difficulties in the search for and administration of information and data. This proficiency, essential for developing learning content, has been considered a foundational skill required for preparing remote classes, alongside competence in using technology. Therefore, to facilitate teachers' digital literacy, it is essential to establish a systematic competency education framework that emphasizes the fundamental aspects of digital literacy, including

understanding and using technology (Kundu & Bej, 2021), as well as exploring and managing information and data (Wen & Shih, 2008).

Second, digital ethics and safety encompassed digital etiquette, personal information protection, copyright preservation, and digital identity. However, elementary school teachers primarily encountered the most significant challenges in comprehending and abiding by copyrights laws. Copyright laws are an essential element that must be adhered to when creating digital content (Campidoglio et al., 2009). The government required copyright adherence when procuring, creating, and adapting educational materials, and they provided teachers with guidelines. Without clear guidelines on copyrights, producing high-quality learning materials becomes challenging; learning content that does not abide by copyright laws has restrictions on its use. For example, to produce video learning content containing human faces for learning purposes, prior consent to use copyrighted human images is required. This means that not only technological proficiency but also comprehension and use of copyrights influence the creation of learning content.

Third, the difficulty of interaction, reported as a disadvantage of distance learning, was also experienced by the teachers who participated in this study. In particular, as suggested in previous research (Kruszewska et al., 2022), there were communication difficulties due to the lack of smooth interaction between students and teachers. This issue was also connected to digital learning and teaching strategies. Specifically, it was necessary to apply teaching strategies that promoted active interactions with students (Tsai & Machado, 2002). Given that elementary school teachers experienced difficulties in employing various digital teaching and learning methods, teachers must develop the ability to use teaching activities and methods that can be effectively used in distance learning in order to strengthen communication between students and themselves. Examples included the use of online discussion boards (Hsieh, 2017; Fanguy et al., 2023) and the Zoom chat box (Nash et al., 2023) to facilitate discussion of course content, as well as pop quizzes (Salas-Morera et al., 2012) to measure students' comprehension of course contents.

Fourth, digital problem-solving has emerged as a component of digital literacy that has attracted recent attention (UNESCO, 2018). Teachers often experienced challenges in solving problems using digital devices based on critical thinking, creative thinking, logical thinking, and computational thinking. Despite recognizing that digital literacy aids students in digital problem-solving, teachers have encountered challenges in guiding the cultivation of students' digital problem-solving abilities. It can be assumed that this has been due to the lack of sufficient teacher competence in digital problem-solving. Therefore, there is a need not only to enhance teachers' digital problem-solving skills but also to support the development of students' digital problem-solving abilities through various instructional methods.

Implications for Fostering Digital Literacy Among Elementary School Teachers

The findings from this study suggested several implications with regard to enhancing teacher digital literacy in order to support students' digital literacy. First, to enhance their own digital literacy in the context of distance learning, teachers require strengthening in their use of a range of digital devices. The ability to use digital devices is one of the most basic components of digital literacy. As students engage in distance learning using various digital devices, teachers need advanced skills that go beyond simply handling and using computers such as such as the ability to log in to Web pages, upload data, and navigate Websites. This proficiency level needs to include the use of various online platforms and content creation using digital

devices. In addition, teachers must be able to assist students who encounter difficulties with digital devices. The results suggested that teachers must strive to deepen their understanding and use of digital devices.

Second, it was evident that strengthening both online and offline networks among teachers for sharing information, resources, and instructional strategies is essential. In the context of COVID-19 remote teaching, teachers collaborated to share diverse materials and instructional approaches for distance learning, thereby providing mutual support. While teacher collaborative communities took various forms during the pandemic, there is a need to systematically organize and operate these networks to enhance their effectiveness. Notably, the interview findings of experienced teachers underscored the substantial assistance gained through teacher collaboration, particularly in content creation and use of online platforms. This highlighted the need to establish a systematic network framework to foster a self-sustaining ecosystem for distance education through teacher collaboration.

Third, regarding digital ethics, the results suggested that the provision of accurate guidelines related to digital copyright protection and related training are necessary. Elementary school teachers indicated that they experienced many difficulties in creating digital learning content. One of the reasons for this is that elementary school teachers were not technologically proficient, but another was their lack of knowledge regarding copyright laws. Therefore, it is necessary to create more sophisticated copyright guidelines in order to train teachers to use copyrighted material in an ethical manner.

Fourth, there is a need to expand professional development opportunities in digital pedagogy to enable teachers to select and apply suitable digital teaching methodologies for the educational context. Teachers perceived that effective instructional strategies varied, based on the nature of the curriculum, and accordingly, they chose content-centred instruction or real-time interactive sessions tailored to their educational circumstances. Considering that the required teaching and learning strategies differed according to the types of lessons, such as theoretical, discussion-based, or experimental lessons, it is necessary to consider ways to expand opportunities for digital pedagogy training to teachers so they can apply effective instructional strategies suitable for educational settings (Doucet et al., 2020). It was also evident that customized digital pedagogy training, considering students' characteristics, is crucial to support individualized education.

Fifth, there is a need to enhance teachers' digital problem-solving competencies to support students in cultivating the essential skill of digital problem-solving demanded by future societies. Despite recognizing the significance of improving students' critical thinking, creativity, logical reasoning, and computational thinking abilities, teachers faced challenges in effectively fostering students' digital problem-solving skills. Given the recent expansion of coding education and the emphasis on learner-centred instruction, providing opportunities for educators to enhance their own digital problem-solving competencies is crucial to effectively nurture students' digital problem-solving abilities.

Conclusions

The purpose of this study was to analyse the experiences related to digital literacy among elementary school teachers in the context of remote teaching, and to derive insights for enhancing teachers' digital literacy to support students' digital literacy. The research findings revealed that elementary school teachers encountered difficulties in students' digital device-related problem-solving, designing digital problem-solving lessons, and facilitating communication between students and teachers within the remote teaching scenario. Additionally, teachers recognized the need to overcome these challenges through enhancing teachers' technological competencies, strengthening digital pedagogical approaches, and establishing and activating networks among teachers. The significance of this study was that it explored the digital literacy difficulties of elementary school teachers who experienced online education during the pandemic and revealed what support was needed to cultivate teacher digital literacy. Furthermore, given that elementary school students experienced many difficulties during pandemic-induced distance education, this study extracted insights for improving elementary school teachers' digital literacy to teach elementary school students. However, it is important to note that the interview sample was limited to five participants in charge of upper grades. Although this study included a small number of subjects, this sample size is common for this type of research (e.g., Hara, 2000; Lee, 2018; Pathak et al., 2011). Future research should include teachers in charge of lower grades in order to provide more comprehensive and in-depth research results.

Despite these limitations, this study will be of value to practitioners, as well as the administrators, because it brings to light the difficulties experienced by elementary school teachers providing distance education during the COVID-19 pandemic: (a) understanding digital copyright, (b) guidance with digital problem-solving, and (c) using various digital teaching methods. Given that various forms of blended learning have become more common since the pandemic, the results of this study are expected to help improve teacher professionalism for blended learning, specifically with regard to the online instructional components. This research not only reinforced the findings of previous studies by delving into the difficulties and obstacles of remote teaching but also provided practical insights into enhancing digital literacy, a topic that has garnered recent attention.

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