frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 03 November 2022
DOI 10.3389/feduc.2022.929191

Check for updates

OPEN ACCESS

EDITED BY
R. Ahmad Zaky El Islami,
Universitas Sultan Ageng Tirtayasa, Indonesia

REVIEWED BY
Usmeldi Usmeldi,
Padang State University, Indonesia
María Dolores Díaz-Noguera,
Seville University, Spain
Nguyen Van Bien,
Hanoi National University of Education, Vietnam
Indah Juwita Sari,
Universitas Sultan Ageng Tirtayasa, Indonesia
Aceng Hasani,
Universitas Sultan Ageng Tirtayasa, Indonesia
Zulfiani Zulfiani,
Syarif Hidayatullah State Islamic University Jakarta, Indonesia

*CORRESPONDENCE
Muhammad Kristiawan
muhammadkristiawan@unib.ac.id

SPECIALTY SECTION
This article was submitted to Teacher Education, a section of the journal Frontiers in Education

RECEIVED 28 April 2022
ACCEPTED 30 September 2022
PUBLISHED 03 November 2022

CITATION
Bentri A, Hidayati A and Kristiawan M (2022) Factors supporting digital pedagogical competence of primary education teachers in Indonesia. *Front. Educ.* 7:929191. doi: 10.3389/feduc.2022.929191

COPYRIGHT
© 2022 Bentri, Hidayati and Kristiawan. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Factors supporting digital pedagogical competence of primary education teachers in Indonesia

Alwen Bentri [1], Abna Hidayati [1] and Muhammad Kristiawan [2]*

[1]Department of Curriculum and Educational Technology, Faculty of Education, Universitas Negeri Padang, Padang, Indonesia, [2]Department of Science Education, Faculty of Education, Universitas Bengkulu, Bengkulu, Indonesia

Teachers must have digital pedagogical competency in order to instruct their pupils in the 4.0 industrial revolution age. The creative ability of educators in West Sumatra is insufficient. As a result, they must be able to employ a variety of learning strategies. The goal of this research is to discover the factors that contribute to teachers' mastery of digital pedagogical competence and to analyze their digital pedagogical competence. This study used a sample size of 94 teachers from three locations, namely, Padang, Bukit Tinggi, and Solok, based on their educational level, age, and gender. The information was gathered through the use of questionnaires, which had been verified for validity and reliability. The findings revealed that there are characteristics that promote instructors' ability to construct digital tools for analysis and assessment. It is suggested that systematic training must be provided for the development of digital pedagogical competency.

KEYWORDS

competence, digital pedagogy, creation, teacher, primary education

Introduction

Digital pedagogical competence is a skill needed by teachers in the 4.0 industrial revolution era. According to the previous study, the skill of elementary school teachers to design digital learning is low at 40%. Meanwhile, due to the COVID-19 pandemic, almost 100% of learning is performed online based on the instruction of the Minister of Education and Culture, Nadiem Makarim. Unfortunately, many teachers are not allowed to upgrade their skill in digital (Dangwal and Srivastava, 2016; Loucks and Ozogul, 2020). At present, teachers are needed to prepare students who are ready to face the future (Kuzminska et al., 2019; Toktarova and Semenova, 2020; Alghamdi and Al-Ghamdi, 2021). In this regard, they are

required to design and provide meaningful digital learning for the children to acquire knowledge about computation, creativity, collaboration, communication, critical thinking, and compassion as well as higher order thinking skills (Tan et al., 2010; Febliza and Okatariani, 2020; Toktarova and Semenova, 2020). On the contrary, the inability to develop online learning influences the low quality of graduates. In addition, data showed that the quality of students' reading, math, and science skills in Indonesia is low, and PISA stated that the average standard of Indonesian students is at a lower level compared to other Asian countries (Sälzer, 2018).

At present, digital pedagogy is an important part of education (Solikin and Komalasari, 2017; Bentri, 2018; Hidayati et al., 2020). This skill includes not only the use of technological tools but also the competence of teachers to utilize them to support learning (Ahmad, 2020; Hendri Nofri, 2020). It is necessary because students are the next generation who must be familiar with technology (Hidayati et al., 2020; Prastiyono et al., 2021). Furthermore, based on the data submitted by the director-general and educational staff, only 40% of teachers are ready to adapt to digital literacy. Consequently, the Indonesian government has developed a program to train at least 10,000 teachers per year to carry out this act (Hendri Nofri, 2020).

According to Redecker (2017), there are six domains or levels along which educators' digital competence typically develops. For each domain, a role descriptor is provided which reflects the particular focus of digital technology use typical for the competence stage. These role descriptors also relate to an educator's relative strengths and roles within a professional community. Knowledge on digital competence related to organizational infrastructures and strategic leadership is sparse (Pettersson, 2018). Digital competence is defined as the set of knowledge, skills, attitudes, abilities, strategies, and awareness that are required when using information and communication technologies (ICTs) and digital media to perform tasks, solve problems, communicate, manage information, collaborate, create and share content, and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure, participation, learning, and socializing (Pettersson, 2018).

A1 (Newcomer)

Newcomers are aware of the potential of digital technologies for enhancing pedagogical and professional practice. However, they have had very less contact with digital technologies and use them mainly for lesson preparation, administration, or organizational communication. Newcomers need guidance and encouragement to expand their repertoire and to apply their existing digital competence in the pedagogical realm (Redecker, 2017).

A2 (Explorer)

Explorers are aware of the potential of digital technologies and are interested in exploring them to enhance pedagogical and professional practice. They have started using digital technologies in some areas of digital competence, without, however, following a comprehensive or consistent approach. Explorers need encouragement, insight, and inspiration, e.g., through the example and guidance of colleagues, embedded in a collaborative exchange of practices (Redecker, 2017).

B1 (Integrator)

Integrators experiment with digital technologies in a variety of contexts and for a range of purposes, integrating them into many of their practices. They creatively use them to enhance diverse aspects of their professional engagement. They are eager to expand their repertoire of practices. However, they are still working on understanding which tools work best in which situations and on fitting digital technologies to pedagogic strategies and methods. They just need additional time for experimentation and reflection, complemented by collaborative encouragement and knowledge exchange to become experts (Redecker, 2017).

B2 (Expert)

Experts use a range of digital technologies confidently, creatively, and critically to enhance their professional activities. They purposefully select digital technologies for particular situations and try to understand the benefits and drawbacks of different digital strategies. They are curious and open to new ideas, knowing that there are many things they have not tried out yet. They use experimentation as a means of expanding, structuring, and consolidating their repertoire of strategies. They are the backbone of any educational organization when it comes to innovating practice (Redecker, 2017).

C1 (Leader)

Leaders have a consistent and comprehensive approach in using digital technologies to enhance pedagogic and professional practices. They rely on a broad repertoire of digital strategies from which they know how to choose the most appropriate for any given situation. They continuously reflect on and further develop their practices. By exchanging with their peers, they keep updated on new developments and ideas. They are a source of inspiration for others, to whom they pass on their expertise (Redecker, 2017).

C2 (Pioneer)

Pioneers question the adequacy of contemporary digital and pedagogical practices, of which they themselves are leaders. They are concerned about the constraints or drawbacks of these practices and are driven by the impulse to innovate education even further. They experiment with highly innovative and complex digital technologies and/or develop novel pedagogical approaches. They are a unique and rare species. They lead innovation and are a role model for younger teachers (Redecker, 2017).

According to the findings of previous study, instructors' grasp of digital pedagogical competency remains inadequate. Teachers' skills to use information technology in learning remain limited, as does their knowledge of simple programs for creating information technology-based media (Irwansyah and Hardiah, 2020). According to our observations in Padang City, only 4 of 10 instructors who were asked for information were able to build information technology-based media. Three teachers admitted that they were ignorant of the effort to generate instructional materials for Internet dissemination. The teacher's communication with students is confined to WhatsApp groups (Ernawati and Safitri, 2018; Hernawan et al., 2021).

However, the findings revealed that they are only trained to advance educational techniques, create conventional learning media, and increase other traditional pedagogic skills, but they seldom understand how to improve their digital pedagogical competence (Ottestad et al., 2014; Väätäjä and Ruokamo, 2021).

Respondent interviews revealed that traditional training has been used to increase competency, but it has mostly focused on one aspect of learning, such as creating online media and establishing online assessments. Specifically, integrated practice for teachers to advance in this capacity, particularly digital pedagogy, has not been developed (Ernawati and Safitri, 2018). It includes their capacity to create and distribute digital learning goods (Ottestad et al., 2014; Sailin and Mahmor, 2018; Hidayati and Bentri, 2022). Another study found that instructors' grasp of digital teaching ability (DDC) is lacking, requiring a curriculum and training to improve their competence (Fernadez Batanero et al., 2021; Widikasih et al., 2021). According to the measures of the digital competence framework, teachers' understanding of digital competence remains insufficient (Vuorikari et al., 2022).

Furthermore, this study tries to identify elements that encourage primary school teachers to develop digital pedagogical competency through the creation of specific products. The uniqueness is in identifying the primary ones that can be tuned for improvement. Furthermore, previous study has gathered data on teachers' digital skills. However, it has not adequately stated the aspects that might improve product design talents. In this regard, the research discovered numerous elements that influence instructors' digital pedagogical competence, which are anticipated to serve as a reference in the creation of programs to strengthen such capacity.

In this research, we identify the factors that contribute to teachers' mastery of digital pedagogical competence and investigate the digital pedagogical competence of primary school teachers in West Sumatra, as well as the influence on their capacity to generate digital commodities.

Materials and methods

The descriptive quantitative approach was applied in this study. Data were collected through questionnaires delivered in the cities of Padang, Bukit Tinggi, and Solok. As they already have great certification, SDN A (35 teachers), SD B (35 teachers), and SD C (35 teachers) were picked as samples. Similarly, the three sample locations were chosen for their representation of West Sumatra and high educational standards. There were 100 samples; however, 6 questionnaires did not meet the requirements and, hence, could not be tallied. Furthermore, these were evaluated by specialists in order to identify elements that promote primary school teachers' digital pedagogical competency. Experts in digital media and learning material validate the curriculum at the elementary school level. The correlation value of the questionnaire, 0.2028, is larger than the 0.195 in Pearson's table of correlation coefficient "r" product moment. As a result, the questionnaire is deemed legitimate. The questions are then distributed using Google forms. In addition, using the SmartPLS tool, field data were investigated using path analysis.

Results

The following data was acquired using questionnaires delivered to respondents at the primary education level of Elementary and Junior High Schools in the study region, this study's respondents were female (79.78%), male (20.21%), and had a graduate (23.40%) or undergraduate (76.59%) education level. Furthermore, age reveals that the majority of people are under 30 years old (46.80%), under 40 years old (39.36%), under 50 years old (8.5%), and under 60 years old (5.32%).

According to the statistics, respondents with primary education are mostly females between the ages of 20 and 40 years, with undergraduate education. As a result, instructors are already in a productive age, and their digital pedagogical competency may be optimized. The researchers next perform validity and reliability testing on the created questionnaires. With a correlation value of 0.2028, the data demonstrate that they are dependable to utilize.

In addition to the SPPS application, we use the SmartPLS technique to determine the key loading factor and the link between variables and indicators, which becomes the analytical tool. This is done to make the device suitable for measuring the preset variable. The factor analysis seeks to discover the most

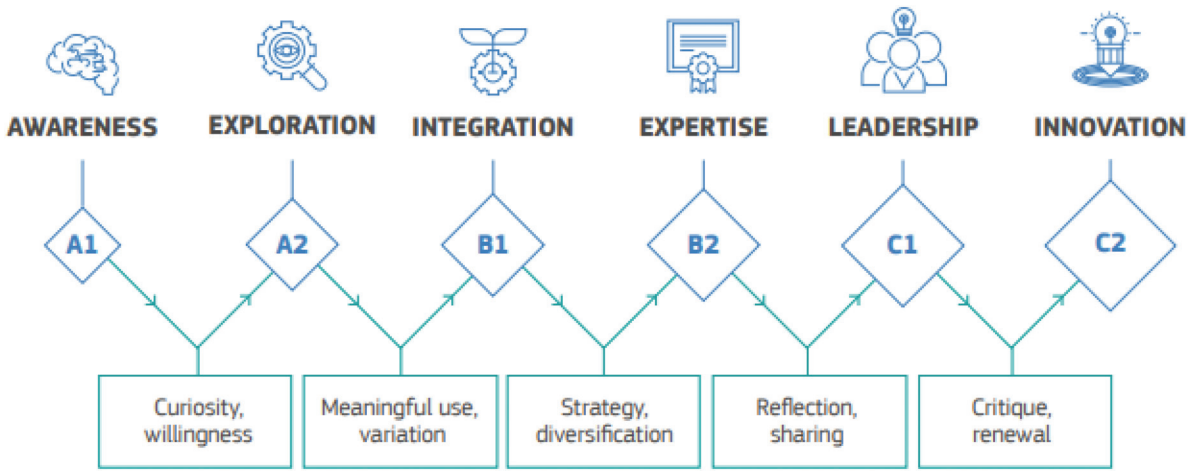

FIGURE 1
Six domains of digital competence.

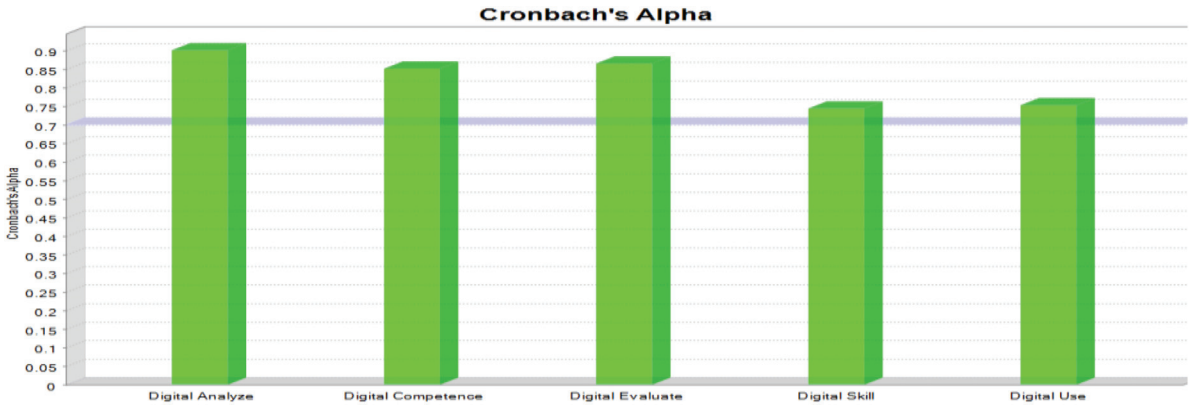

FIGURE 2
Cronbach's alpha analysis.

critical factors in developing instructor's digital pedagogical abilities. This criterion specifies which aspects of teacher digital competency must be addressed. The results can be seen in Table 1.

Table 1 shows that the link between the indicators and questionnaires is adequate because the average is more than 0.500, making it usable. If the Cronbach's alpha (0.941) of a questionnaire is more than 0.6, it is considered trustworthy.

Following the validity and reliability tests, the SmartPLS program is used to analyze the association between variables. The findings indicate a relationship between a teacher's capacity to understand digital items and generate multimedia learning.

The reliability and validity test findings can be used because the average value is greater than 0.6. As a result, the questionnaires employed are valid and dependable, resulting in correct results in the analysis. All the questions' components are authentic and reliable, allowing the findings to be processed and investigated further. The digital component of the study has a high level of validity (0.901), indicating that the question is particularly relevant to the elements of digital pedagogy that will be uncovered. This is also supported by Cronbach's alpha histogram as follows.

Furthermore, information relevant to the above results is derived based on composite reliability data, and because the average calculation surpasses the criterion of 0.6, the questionnaires utilized are valid and reliable.

Following that, an inner model analysis is performed to establish the characteristics that influence the mastery of digital pedagogical competence and the primary indicators to assist instructors' performance, particularly in developing digital goods. The exam results will be utilized subsequently to determine the major factors that will form this ability for teachers in Indonesia. Furthermore, the data are processed using path analysis as follows.

The data analysis reveals that digital analysis has a positive and significant influence on competence at the alpha level of 0.000, with a T statistic value of 4.297, which is more than the T-table value of 0.2028. Furthermore, at the alpha level of 0.035, digital assessment has a simultaneous reaction with T statistics bigger than the T-table, namely, 2.116. This suggests that the two components are significant determinants in enhancing primary school teachers' digital pedagogical competency in Indonesia (Quiroz, 2020). Based on the test, the following model can be obtained.

Figure 3 shows that the elements that need to be improved to get digital pedagogical competency are KD4 (11.027), KD3 (9.894), and KD2 (14.659). Teachers, in particular, may optimize knowledge in order to discover elements that can produce digital learning media and can use social networking sites to exchange information online. Furthermore, the dominating components developed in the digital use include PD3 (15.719), PD4 (18.141), and PD5 (16.253), indicating that they have studied learning materials and online texts; had a blog, page references, and YouTube channels; and have utilized different search capabilities. Similarly, the primary factors for the digital analysis aspect are MD5 (23.535), MD4 (15.164), and MD2 (16.285), indicating that they know and practice how to join the digital community, have the means to connect digitally, and have implemented e-learning. Furthermore, in the digital evaluation detail, the sections that support this competency are ED2 (18.737), ED3 (30.583), and ED4 (20.739), in which teachers already have content operation and storage instruments, reference management tools, as well as virus and malware security methods.

Discussion

Digital analysis is the most important aspect in improving competency because it encourages instructors to study and practice how to join the digital community, interact digitally, and apply e-learning (Malicoban and Castro, 2022). The gender

TABLE 1 Loading factor test of teachers' digital pedagogical competence.

Indicator	Digital analysis	Digital competence	Digital evaluation	Digital cognitive	Digital use
CD1				0.760	
CD2				0.548	
CD3				0.760	
CD4				0.746	
CD5				0.887	
CD6				0.807	
ED1		0.630			
ED2		0.839			
ED3		0.876			
ED4		0.844			
ED5		0.829			
KD1			0.630		
KD2			0.807		
KD3			0.751		
KD4			0.699		
KD5			0.569		
MD1	0.747				
MD2	0.799				
MD3	0.756				
MD4	0.781				
MD5	0.831				
MD6	0.709				
MD7	0.765				
MD8	0.749				
PD1					0.599
PD2					0.569
PD3					0.777
PD4					0.799
PD5					0.802
PD6					0.695

TABLE 2 Reliability and validity test results.

Matrix	Cronbach's alpha	Rho-A	Composite reliable
Digital analysis	0.901	0.910	0.920
Digital competence	0.851	0.887	0.889
Digital evaluation	0.865	0.889	0.903
Digital skill	0.744	0.781	0.823
Digital use	0.753	0.814	0.817

breakdown of respondents reveals that women account for 79.78% of all respondents. This indicates that there are more female teachers than male teachers, and the most common level of education is a bachelor's degree (76.59%). As many as 46.80% of instructors are under the age of 30 years. This enables more advanced digital learning resource analysis capabilities.

In this instance, digital skills are developed not just through school-provided training and courses. Teachers must take an active part in expanding their expertise (Howell, 2005). The findings show that instructors in many countries, including those with restricted Internet access, believe that using the Internet may improve learning, particularly in meeting the information needs of teachers and pupils (Thu and Penh, 2022). Their engagement in digital communities is critical to increase digital pedagogical competency (Admiraal et al., 2017; Khoiri et al., 2022). Those that participate can share their experiences to gain a better understanding. Furthermore, they can go from being classroom specialists to being able to communicate online and increase their learning abilities (Rency Riwayanti, 2019; Esteve-Mon et al., 2020; Hidayati et al., 2020; Toktarova and Semenova, 2020). Teachers can train pupils utilizing e-learning, both free platforms and those particularly designed for school requirements, to indirectly aid develop their digital pedagogical competency (Kuzminska et al., 2019; Irwansyah and Hardiah, 2020; Thongbunma et al., 2021).

In this idea, digital pedagogical competency is described as the teacher's capacity to apply relevant knowledge and skills through the use of technology so that students can recall, interpret, implement, evaluate, and produce information (Ghomi and Redecker, 2019; Stefaniak, 2020; Budiamai et al., 2021; Permana and Widodo, 2022). Educators must be able to teach by utilizing multimedia technologies (Tan et al., 2010; Stefaniak, 2020; Khoiri et al., 2022). Teachers with digital pedagogy skills can produce multimedia, online quizzes, and online learning administration to improve learning (Titin, 2022; Widyastuti et al., 2022).

However, without this capability, the learning process, which has turned to technology in the light of the COVID-19 epidemic, would undoubtedly be tough. Nowadays, people are surrounded by the Internet and a series of digital technologies. The development of social structure and trends in using technology has already changed not only how we live but also how we acquire knowledge. Due to the outbreak of the COVID-19 pandemic, regular traditional teaching activities have been suspended (Zhao et al., 2021). To facilitate more

TABLE 3 Path analysis test results.

Matrix	Original sample	Standard	T-statistic	*P*-values
Digital analysis-digital competence	0.439	0.102	4.297	0.000
Digital evaluation-digital competence	0.262	0.124	2.116	0.035
Digital skill-digital competence	−0.062	0.112	0.551	0.582
Digital use-digital competence	0.136	0.113	1.202	0.230

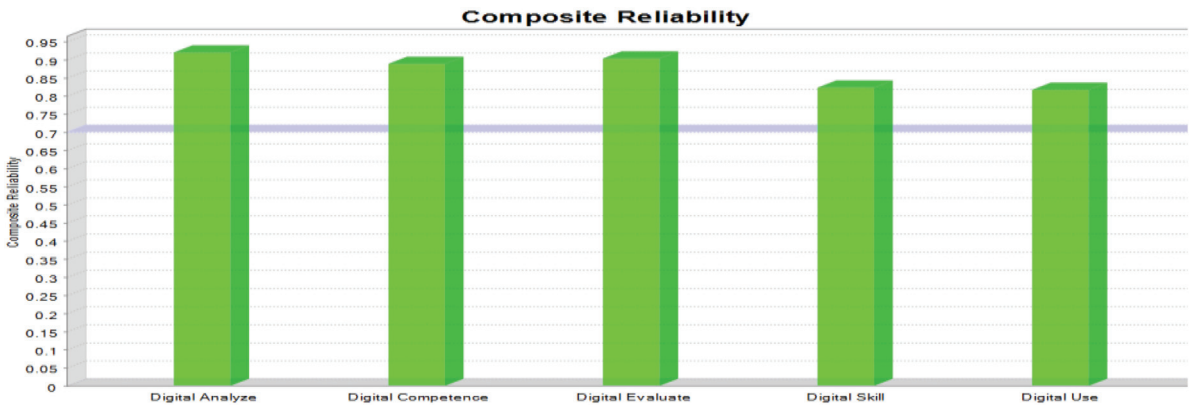

FIGURE 3
Composite reliability histogram.

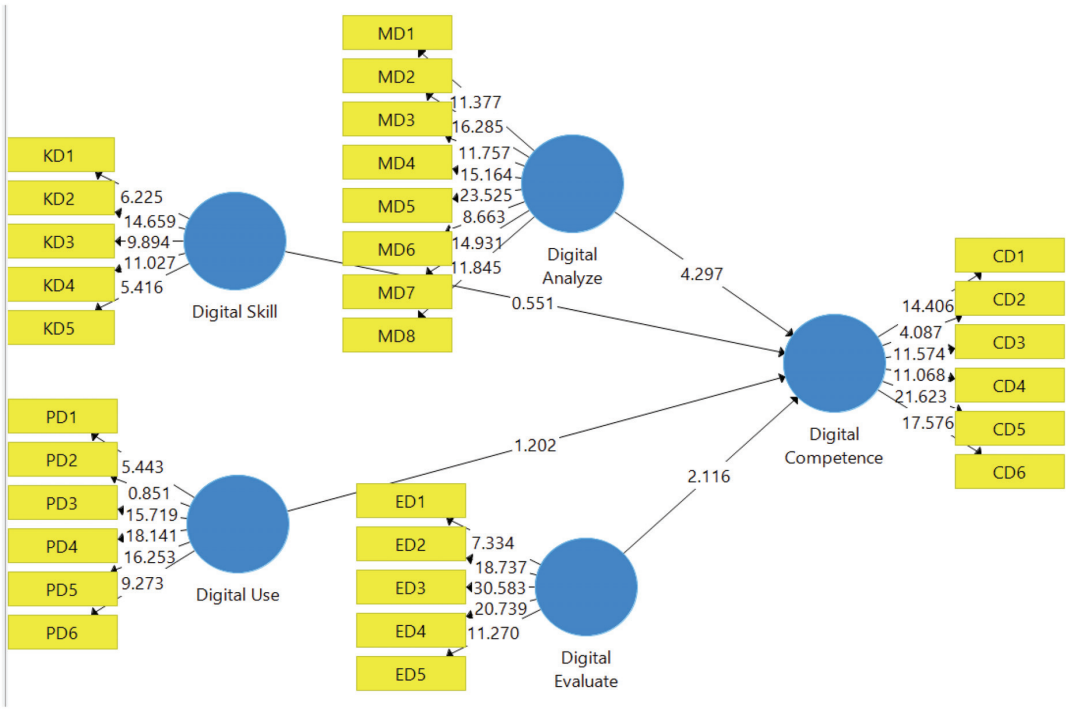

FIGURE 4
Digital competence analysis model.

effective learning, teachers must be technologically literate. Digitization in education improves learning and increases student involvement significantly (McCoy et al., 2016; Hidayati and Bentri, 2022; Titin, 2022; Widyastuti et al., 2022). Digital tools, such as mobile learning, improve knowledge transmission. Several studies show that instructors are increasingly using mobile learning in the training process and other competency developments (Esteve-Mon et al., 2020; Ardiani et al., 2022). Furthermore, digitization is accelerating, with a variety of social media platforms being employed in education (Fitria et al., 2021; Rojas et al., 2021). Many social media platforms are modifying their learning functions since they can boost students' inventiveness (Rojas et al., 2021; Hernawan et al., 2021). Teachers may utilize social media to provide pupils with an engaging learning resource (Al-hunaiyyan et al., 2017; Štemberger and Konrad, 2021). Due to the utilization of current and engaging materials, social media can assist boosting students' motivation to learn independently (Leung and McGrath, 2010; Salsa et al., 2022). The utilization of knowledge of digitization can aid in classroom management by involving students in active learning, particularly when lecturers are unable to be present in the classroom (Gemilang et al., 2022). Online objective examinations can assist students in developing their cognitive talents. If required, teachers can manage and examine test results with students again (Quiroz, 2020; Danpradit et al., 2021).

Teachers should ideally be technologically capable and knowledgeable (Redecker, 2017; Loucks and Ozogul, 2020; Thongbunma et al., 2021; Salsa et al., 2022) as well as being able to apply it in education. Moreover, today's future teachers are digital natives who use technology in everyday life and would benefit greatly from implementing these applications in the teaching-learning process (Zhao et al., 2021). However, in the digital pedagogy era, it is not only vital to provide learning to students but also to collaborate their knowledge with them (Hidayati, 2019; Ogbonnaya et al., 2020). The training created with an in-service system is required to enhance this (Ogbonnaya et al., 2020; Alghamdi and Al-Ghamdi, 2021). Furthermore, this skill may be enhanced in the context of in-service teacher training by leveraging the online teleconference technology. In addition, teachers from Indonesia, particularly West Sumatra, have joined the Teacher Working Group (KKG).

The evolution of information technology-based learning also needs continuous state involvement in the creation of equipment such as electricity and Internet networks, which allows instructors to apply digital pedagogical expertise to improve the learning process (Al-Ansi et al., 2021; Thongbunma et al., 2021). Digital competence has become a key concept in discussions of the kind of skills and understanding people need in the digital era (Gallardo et al., 2015; Yunus and Syafi'i, 2020). Digital competence is the technical use of ICT, which is more broadly known as

knowledge application or twenty-first century skills. This will enable us not only to further advance the knowledge generation but also to identify the key aspects of this essential competence for education in the twenty-first century (Gallardo et al., 2015).

Conclusion

According to the specifics of the area in Indonesia, particularly West Sumatra, the elements supporting the development of digital pedagogical competency of primary school teachers may be improved in two ways, namely, evaluation (2.116) and analysis (4.297). These have a huge impact on their ability to progress. Furthermore, the characteristics indicate that they have content management and storage, reference control, and virus and malware security solutions. Furthermore, they understand how to join the digital community, interact online, and engage in e-learning. Overall, it is still advised to encourage instructors to participate in training to acquire these components and develop their talents.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

AB contributed as thinker and contributed to the data review and data collection. AH contributed to the journal review and translation. MK contributed to proofread and review data analysis. All authors contributed to the article and approved the submitted version.

Acknowledgments

We are grateful to the Universitas Negeri Padang's Institute for Research and Community Service (LP2M) for sponsoring this research under contract number 753/UN35.13/LT/2021. We also appreciate the Institute for conducting an ethical test that was approved by the research ethics division.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer UU declared a shared affiliation with the authors AB and AH to the handling editor at the time of review.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Admiraal, W., Felix van, V., Frans, K., Bob, K., Ben, S., Sanne, W., et al. (2017). Preparing pre-service teachers to integrate technology into K–12 instruction: Evaluation of a technology-infused approach. *Technol. Pedagog. Educ.* 26, 105–120. doi: 10.1080/1475939X.2016.1163283

Ahmad, N. A. (2020). Learning reading skills independently using interactive multimedia. *Univ. J. Educ. Res.* 8, 2641–2645. doi: 10.13189/ujer.2020.080647

Al-Ansi, A. M., Garad, A., and Al-Ansi, A. (2021). ICT-based learning during covid-19 outbreak: Advantages, opportunities and challenges. *Gagasan Pendidik. Indones.* 2:10. doi: 10.30870/gpi.v2i1.10176

Alghamdi, A. K. H., and Al-Ghamdi, N. A. (2021). Elementary teachers' thoughts about distance education and learning 21st-century skills during covid pandemic. *Int. J. Learn. Teach. Educ. Res.* 20, 33–50. doi: 10.26803/ijlter.20.3.3

Al-hunaiyyan, A., Al-Sharhan, S., and Alhajri, R. (2017). A new mobile learning model in the context of smart classroom environment. *Int. J. Interact. Mob. Technol.* 11, 39–56.

Ardiani, V., Saifuddin, M. F., and Dahlan, U. A. (2022). Problem-based learning implementation using blended learning on environmental pollution concepts. *Gagasan Pendidik. Indones.* 3, 1–11. doi: 10.30870/gpi.v3i1.14833

Bentri, A. (2018). The implementation of affective evaluation in elementary school curriculum in Padang, West Sumatra Province, Indonesia. *Int. J. Eng. Technol.* 7, 108–111. doi: 10.14419/ijet.v7i4.9.20629

Budiamai, B., Komarudin, K., Nuruddin, N., and Kustandi, C. (2021). Learning design on social studies through digital book in senior high school. *Int. J. Interact. Mob. Tecnol.* 15, 154–166. doi: 10.3991/ijim.v15i09.18435

Dangwal, K. L., and Srivastava, S. (2016). Digital pedagogy in teacher education. *Int. J. Inf. Sci. Comput.* 3:67. doi: 10.5958/2454-9533.2016.00008.9

Danpradit, P., Kongkumnerd, T., and Boonplian, P. (2021). Forwarding strategies for online multiple-choice tests. *J. Green Learn.* 1, 52–60.

Ernawati, E., and Safitri, R. (2018). Analisis kesulitan guru dalam merancang rencana pelaksanaan pembelajaran mata pelajaran fisika berdasarkan kurikulum

2013 di Kota Banda Aceh. *J. Pendidik. Sains Indones.* 5, 50–58. doi: 10.24815/jpsi.v5i2.9817

Esteve-Mon, F. M., Llopis, M. A., and dell-Segura, J. A. (2020). Digital competence and computational thinking of student teachers. *Int. J. Emerg. Technol. Learn.* 15, 29–41. doi: 10.3991/ijet.v15i02.11588

Febliza, A., and Okatariani, O. (2020). Pengembangan instrumen literasi digital sekolah, Siswa Dan Guru. *J. Pendidik. Kim. Univ. Riau.* 5:1. doi: 10.33578/jpk-unri.v5i1.7776

Fernadez Batanero, J. M., Román-Graván, P., MontenegroRueda, M., López-Meneses, E., and Fernández-Cerero, J. (2021). Digital teaching competence in higher education: A systematic review. *Educ. Sci.* 11, 1–10.

Fitria, H., Maksum, A., and Kristiawan, M. (2021). Covid-19 pandemic: Educational transformation at paramount elementary school Palembang. *AL-ISHLAH J. Pendidik.* 13, 934–939. doi: 10.35445/alishlah.v13i2.647

Gallardo, E., Esteve, F., Marqués, L., and Minelli, J. (2015). "Digital competence in the knowledge society [La competencia digital en la sociedad del conocimiento]. *MERLOT. J. Online Learn. Teach.* 11, 1–16.

Gemilang, I., Bernard, C., Djami, N., Kristen, U., and Wacana, S. (2022). Integrated technology for classroom management strategies in a computer-assisted language learning. *J. Pendidik. Indones. Gemilang* 2, 70–94.

Ghomi, M., and Redecker, C. (2019). "Digital competence of educators (DigCompEdu): Development and evaluation of a self-assessment instrument for teachers' digital competence," in *Proceedings of the 11th international conference on computer supported education: CSEDU*, 1, 541–548. doi: 10.5220/0007679005410548

Hendri Nofri, S. A. (2020). Pengembangan multimedia pratikum *Berbasis* laboratorium virtual (virtual laboratory/Vi-Lab) pada Materi perkualiahan komputer di jurusan KTP FIP UNP. *Educ. Technol.* 8, 1–5.

Hernawan, A. H., Dewi, L., Fadlillah, A. F., and Setiawan, B. (2021). Students ' attitudes and perceptions of smart online learning through podcast content development. *Interact. Mob. Technol.* 15, 88–106.

Hidayati, A. (2019). The analysis of influencing factors of learning styles, teacher's perceptions and the availability of learning resources in elementary schools in Padang, West Sumatra. *J. Phys. Conf. Ser.* 1185:012149.

Hidayati, A., and Bentri, A. (2022). Supporting factors for the implementation of mobile learning for elementary school students using an authentic approach and real-world activities. *Int. J. Interact. Mob. Technol.* 16, 107–120.

Hidayati, A., Efendi, R., and Saputra, A. (2020). The quality of digital literation early childhood education teachers based on UNESCO standards. *Int. J. Sci. Technol. Res.* 9, 3514–3517.

Howell, J. (2005). *What is a digital pedagogy and why do we need one?? Oxford university press sample chapter*. Oxford: Oxford Univ Press, 1, 3–17.

Irwansyah, and Hardiah, S. (2020). Digital collaboration in teaching and learning activities: The reflexivity study on educational digital empowerment. *Int. J. Learn. Teach. Educ. Res* 19, 355–370. doi: 10.26803/IJLTER.19.10.20

Khoiri, N., Sugandi, K., Siswanto, J., and Skills, C. T. (2022). The validity of the sustainability based argument- driven inquiry to improve students' critical thinking skills. *Gagasan Pendidik. Indones.* 3, 12–23. doi: 10.30870/gpi.v3i1.15115

Kuzminska, O., Mazorchuk, M., Morze, N., Pavlenko, V., and Prokhorov, A. (2019). "Study of digital competence of the students and teachers in Ukraine. *Commun. Comput. Inf. Sci.* 1007, 148–169. doi: 10.1007/978-3-030-13929-2_8

Leung, A. S. M., and McGrath, S. (2010). An effective learning model to support people development: The emerging approach of the Hong Kong institute for vocational education. *Int. Educ. Stud.* 3, 94–106. doi: 10.5539/ies.v3n4p94

Loucks, S., and Ozogul, G. (2020). Preparing business students for a distributed workforce and global business environment: Gaining virtual leadership skills in an authentic context. *TechTrends* 64, 655–665. doi: 10.1007/s11528-020-00513-4

Malicoban, E. V., and Castro, E. J. (2022). Development of a physics laboratory activity kit for the do-it-yourself (DIY) physics equipment and laboratory activity. *Int. J. STEM Educ. Sustain.* 2, 172–179. doi: 10.53889/ijses.v2i2.7

McCoy, L., Lewis, J., and Dalton, D. (2016). Gamification and multimedia for medical education: A landscape review. *J. Am. Osteopath. Assoc.* 116, 22–34. doi: 10.7556/jaoa.2016.003

Ogbonnaya, U. I., Awoniyi, F. C., and Matabane, M. E. (2020). Move to online learning during covid-19 lockdown: Pre-service teachers' experiences in Ghana. *Int. J. Learn. Teach. Educ. Res.* 19, 286–303. doi: 10.26803/IJLTER.19.10.16

Ottestad, G., Kelentrić, M., and Gudmundsdóttir, G. B. (2014). Professional digital competence in teacher education. *Nord. J. Digit. Lit.* 2014, 243–249.

Permana, R. A. H. A., and Widodo, A. (2022). Validity and inter-rater reliability of the scoring rubrics for the science teacher TPACK test instrument. *J. Penelit. Pembeljaran IPA* 7, 27–44. doi: 10.30870/jppi.v8i1.11164

Pettersson, F. (2018). On the issues of digital competence in educational contexts – A review of literature. *Educ. Inf. Technol.* 23, 1005–1021. doi: 10.1007/s10639-017-9649-3

Prastiyono, H., Utaya, S., Sumarmi, S., Astina, I. K., Amin, S., and Aliman, M. (2021). Development of E-Learning, mobile apps, character building, and outdoor study (EMCO learning model) to improve geography outcomes in the 21st century. *Int. J. Interact. Mob. Technol.* 15, 107–122. doi: 10.3991/ijim.v15i07.21553

Quiroz, N. T. (2020). TikTok. *Rev. Argentina Estud. Juv.* 14:e044. doi: 10.24215/18524907e044

Redecker, C. (2017). *European framework for the digital competence of educators*. Luxembourg: Publications office of the European union, doi: 10.2760/159770

Rency Riwayanti, A. H. (2019). Pengembangan modul pembelajaran tematik *Berbasis* pendidikan Karakter di Kelas V sekolah dasar. *J. Basicedu.* 3:8.

Rojas, V. S., Fuentealba, L. F., and Ranjan, R. (2021). Game-based didactic resources as a strategy in foreign language pedagogy. *Int. J. Learn. Teach. Educ. Res.* 20, 195–211. doi: 10.26803/IJLTER.20.12.12

Sailin, S. N., and Mahmor, N. A. (2018). Improving student teachers' digital pedagogy through meaningful learning activities. *Malaysian J. Learn. Instr.* 15, 143–173. doi: 10.32890/mjli2018.15.2.6

Salsa, F. J., Sari, R. T., Muhar, N., and Gusmaweti, G. (2022). The relationship between motivation and learning outcomes of biology subject through distance learning. *Int. J. STEM Educ. Sustain.* 2, 140–147. doi: 10.53889/ijses.v2i2.54

Sälzer, C. (2018). International journal of development education and global learning assessing global competence in PISA 2018: Challenges and approaches to capturing a complex construct. *Int. J. Dev. Educ. Glob. Learn.* 10, 6–20.

Solikin, I., and Komalasari, D. (2017). Aplikasi bahan ajar digital pada Sekolah MA. Miftahul Huda tugu Agung Kab. OKI. *JIK* 8, 63–69.

Stefaniak, J. (2020). A systems view of supporting the transfer of learning through E-service-learning experiences in real-world contexts. *TechTrends* 64, 561–569. doi: 10.1007/s11528-020-00487-3

Štemberger, T., and Konrad, S. Č (2021). Attitudes towards using digital technologies in education as an important factor in developing digital competence: The case of Slovenian student teachers. *Int. J. Emerg. Technol. Learn.* 16, 83–98. doi: 10.3991/ijet.v16i14.22649

Tan, H. Y. J., Kwok, J. W. J., Neo, M, and Neo, T. K. (2010). "Enhancing student learning using multimedia and web technologies: Students' perceptions of an authentic learning experience in a Malaysian classroom," in *Proceedings of the ASCILITE – Australian society for computers in learning in tertiary education annual conference 2010*, (Cyberjaya: Multimedia University), 951–962.

Thongbunma, J., Nuangchalerm, P., and Supakam, S. (2021). Secondary teachers and students' perspectives towards online learning amid the COVID-19 outbreak. *Gagasan Pendidik. Indones.* 2:1. doi: 10.30870/gpi.v2i1.10524

Thu, M. T., and Penh, P. (2022). ICT skills and challenges faced by high school teachers of Inle lake located in the Nyaungshwe township of Shan state in Myanmar. *J. Green Learn.* 2, 29–37. doi: 10.53889/jgl.v2i1.102

Titin, T. (2022). Development of multimedia-based worksheets as a teaching material on sub-material of invertebrates. *J. Penelit. Pembelajaran IPA* 8, 91–107. doi: 10.30870/jppi.v8i1.5139

Toktarova, V. I., and Semenova, D. (2020). Digital pedagogy: Analysis, requirements and experience of implementation. *J. Phys. Conf. Ser.* 1691:012112. doi: 10.1088/1742-6596/1691/1/012112

Väätäjä, J. O., and Ruokamo, H. (2021). Conceptualizing dimensions and a model for digital pedagogy. *J. Pacific Rim Psychol.* 15, 1–12. doi: 10.1177/1834490921995395

Vuorikari, R., Kluzer, S., and Punie, Y. (2022). *DigComp 2.2. The digital competence framework for citizens. With new examples of knowledge, skills and attitudes*. Luxembourg: Publications Office of the European Union. doi: 10.2760/115376

Widikasih, P. A., Widiana, I. W., and Margunayasa, I. G. (2021). Online learning prolems for elementary school students,". *J. Educ. Res. Eval.* 5, 1–10.

Widyastuti, L., Usman, U., and Rifqiawati, I. (2022). The effect of the discovery learning model through the aptitude treatment interaction (ATI) on student learning outcomes on the human motion system concept. *J. Pendidik. Indones. Gemilang.* 2, 111–122.

Yunus, A. A., and Syafi'i, A. (2020). Google classroom as learning platform in teaching writing. *Br. Jurnal Bhs. dan Sastra Inggris* 9, 48–64. doi: 10.3109/0142159X.2015.1020290

Zhao, Y., Pinto Llorente, A. M., and ánchez Gómez, M. C. S. (2021). Digital competence in higher education research: A systematic literature review. *Comput. Educ.* 168:104212. doi: 10.1016/j.compedu.2021.104212