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The role of mobile learning in improving 21st-century teacher competencies: A systematic literature review

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ABSTRACT

The current learning process has entered the 21st-century era, requiring teachers to possess digital learning technology competencies in the teaching and learning process. The 21st-century teacher competencies are known as TPaCK or Technological, Pedagogical, Content Knowledge, which involves integrating technology in designing teaching materials, delivering content, and teaching students. One of the current hot trends in learning, especially in Indonesia, is mobile-based learning or Mobile Learning. The TPaCK framework and mobile-based learning share the similarity of requiring technological learning competencies. Therefore, this research aims to examine efforts to enhance 21st-century teacher competencies using Mobile Learning. The main contribution of this research is to provide empirical evidence on the effectiveness of Mobile Learning in improving teachers' technological competencies. This research serves as an important reference for educators and policymakers in designing strategies for improving teacher competencies based on digital technology. The method used in this research is a Systematic Review with the PRISMA framework. The research results indicate that the implementation of Mobile Learning can create various mobile-based learning media, enabling teachers to enhance their competencies. Moreover, the findings highlight the significant role of Educational Technologists in facilitating learning and improving performance.

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INTRODUCTION

At present, education has entered the 21st-century learning era. Learning continues to improve in terms of learning models, learning strategies, and technology learning. The latest trend that is currently happening is the actualization of technology in learning, specifically Rahmadayanti & Hartoyo (2022) the teaching and learning process in the Merdeka Curriculum where which is also known as Merdeka Belajar to improve the 2013 curriculum by the need to achieve the objectives of national education (Inayati, 2022). However, something is interesting about the development of education in the 21st century, where the curriculum is developed regularly by adjusting knowledge, information, and technology according to the current criteria (Julaeha et al., 2021).

To implement the 21st-century curriculum, teachers must have adequate skills and competencies. A teacher is expected to be able to innovate in teaching, teach competencies by current

trends, and design learning that can bring attraction, happiness, and meaning. The difference between 21st-century learning and conventional, traditional, or classical learning as in the previous era (Inayati, 2022). The educational curriculum is dynamic, experiencing development by adjusting the needs of student' characteristics with their time. In today's 21st-century learning, a teacher must be able to design learning innovations so that the learning process is more meaningful and happy (Cholilah et al., 2023).

Teacher competence in general has been regulated and mandated in Law No. 14 of 2005, namely teaching competence (pedagogic), personality, social, and professional competencies are the competency requirements that a teacher must have. These competencies need to be contextualized and "adjusted" so that teachers are competent in preparing and predicting matters related to the learning needs of learners according to the 21st century (Hamsia et al., 2022). These requirements, along with the development of science, require teachers to have specific 21st-century competencies. As explained by Kemendikbudristek (2021), teachers actively participate in the design of an independent curriculum, which focuses on the material that matters and the development of students' competencies at a particular stage. This allows students to have more in-depth, meaningful, and enjoyable learning without being rushed (Rahmadayanti & Hartoyo, 2022).

Some literacy sources in efforts to upgrade teacher competencies in the 21st-century era, Technological, Pedagogical, Content, Knowledge, or TPaCK competencies are the right framework for 21st-century teacher competencies. Integrating technology in teaching (pedagogy) and delivering material (content) by teachers is a complete framework and can be a unified option that teachers can master in the 21st century. Koehler & Mishra (2009) in this circumstance, teachers are expected to improve their professional skills and create new learning activities. The challenges teachers face when using complex technology to teach (Mardhiati, 2023). Ineffective teaching with technology, there are three main elements: content, pedagogy, and technology, and how these three components interact with each other. The way these three components interact differently in various contexts can lead to different levels and qualities of technology integration in education (Koehler & Mishra, 2009).

Koehler & Mishra (2009) in their research also said that teaching with technology is increasingly complicated given the new technological challenges that teachers face. Practically speaking, most of the technologies considered in the current literature are newer and digital and have some inherent properties that make their direct application difficult. But thanks to the proliferation of scientific publications and knowledge, TPaCK is becoming more intensively promoted to improve teachers' competencies in the 21st century.

Gozali et al., (2023) opined that the national teacher certification program in Indonesia, which is nationally called the Teacher Professional Program, includes TPACK mastery as one of the criteria in the rubric of in-service teachers' micro-teaching evaluation. In addition to its utilization as an assessment instrument, the TPACK survey has been widely reviewed by scholars in studies related to teachers' self-perceptions of their TPACK skills (Castéra et al., 2020; Efwinda & Mannan, 2021; Novita et al., 2022; Roussinos & Jimoyiannis, 2019). The implementation of the TPaCK has a significant positive impact on teachers' skills. By mastering the TPaCK, teachers not only become more competent in using technology but also more innovative in their teaching strategies, ultimately improving student engagement and learning outcomes. The effective integration of technology, pedagogy, and content in the TPaCK makes this framework a very important tool in 21st-century education.

On the sidelines, current educational trends are also experiencing innovation with mobile learning commonly known as "Mobile Learning". The concept of mobile learning is learning that can be done anywhere through mobile devices, meaning that it does not have to be face-to-face in one place directly. Many benefits can be achieved by using this Mobile Learning system. Such as delivering material for learning, finding study sources, and so on. Mobile Learning also has the characteristics of adaptability, namely using mobile devices, laptops, and information technology that is widely used in the teaching and learning process, subject matter can be tailored to the needs and level of progress of each student (Sari & Priatna, 2020).

Mobile Learning as a substitute means students are given the flexibility to choose their preferred learning model. Whether they want to learn using a learning model by (1) using a

conventional learning model, (2) combining a conventional model with technology, or (3) completely using a learning model that integrates technology (Musahrain et al., 2017). How can teachers utilize technology in teaching with these issues in mind? There is no "one best way" to incorporate technology into the curriculum. Instead, integration efforts must be creatively designed for specific subject matter relevant to specific classroom environments. An understanding approach to successful technology integration requires educators to develop new ways of understanding and accommodating this complexity (Koehler & Mishra, 2009). In the 21st-century learning era, digital technology is key to educational success. Teachers' competence in using technology, known as TPaCK (Technological Pedagogical Content Knowledge), is critical to creating effective and relevant learning. This research highlights the urgent need to improve teachers' TPaCK competency through the implementation of Mobile Learning.

Mobile Learning provides flexibility and accessibility, allowing teachers and students to access learning materials anytime and anywhere. It increases the interactivity and adaptability of learning, according to students' individual needs. With the Systematic Literature Review (SLR) method and PRISMA framework, this research collects and analyzes data from various studies to provide practical guidance in the development of teacher competencies. The main contribution of this research is to provide empirical evidence on the effectiveness of Mobile Learning in improving teachers' technological competencies. This research serves as an important reference for educators and policymakers in designing digital technology-based teacher competency improvement strategies. Overall, this research offers practical solutions to the challenges of implementing technology-based learning in the era of Industrial Revolution 4.0, strengthening teachers' ability to integrate technology into teaching.

The three key factors that influence the application of TPACK are instructional factors (teaching and learning issues), curriculum factors (the use of ICT in the school environment), and organizational factors (the logistics of ICT integration in the curriculum) (Majid & Ismail, 2019). Educational technologists play an important role in integrating technology into the learning process. They assist teachers in performing their function as facilitators of learning and performance improvement, ensuring effective and efficient use of technology in the classroom (Bueno et al., 2023; Rossi & Trevisan, 2018).

This literature systematic review (SLR), wants to explore how the competencies of 21st-century teachers, namely TPaCK, can be improved through mobile-based learning or Mobile Learning to suit the needs of 21st-century learning which is currently running with the provisions of the independent learning curriculum. Where the similarity between the two is to actualize technology into learning. So it is hoped that this literature review will create many new ideas and innovative methods in the world of education with the Mobile Learning learning model in improving teacher competence in the 21st century. This research contributes as a reference for every teacher that mobile learning media is a reference for increasing teacher competence in the learning process.

METHOD

This research is a Systematic Literature Review (SLR). A systematic review is an evaluation of a formulated question that uses systematic and explicit methods to identify, select, and critically evaluate relevant research, as well as collect and analyze data from studies covered by the review. The results of the included studies may or may not be analyzed using statistical methods known as meta-analysis (Moher et al., 2010).

This research focused on TPaCK skills as a teacher skill in the 21st-century era that can be improved through mobile learning. To improve TPaCK competence through mobile learning, this study chose this approach for several reasons. One of them is to find out how well teachers can utilize technology in learning that integrates with the Pedagogical Content Knowledge Technology (TPaCK) framework and what things can be utilized from the Mobile Learning learning design. Before conducting the review, the author must prepare research questions to evaluate, namely: Research Question1. How is the TPaCK competency framework a 21st-century teacher competency? Research Question2. How is the learning process based on Mobile Learning in formal schools?

Research Question3. What is the role of mobile-based learning in improving the technological competencies of 21st-century teachers?

This research was analyzed using the Systematic Literature Review (SLR) method. The literature review stage began with a search strategy, where most of the articles to be reviewed were collected from Google Scholar and Research Rabbit. The initial research process began with searching for literature related to the research subject to gather important information. Next, the selection criteria were determined by focusing on keywords such as TPaCK Competency, 21st Century Learning, and Mobile Learning. Articles and journals selected for review should be relevant to the research topic and published by credible sources such as Open Journal Systems (OJS). The authors read the titles and abstracts of the literature to ensure their quality and relevance.

The data extraction process was carried out by selecting eleven published journals related to the selected topics, namely the TPaCK framework in 21st-century learning and Mobile Learning to improve technological competence. These journals were collected over the past five years, from 2019 to 2023, with a focus on Indonesian-language journals. This process ensures that the data obtained is relevant and up-to-date to support the analysis in this study.

RESULTS AND DISCUSSION

Results

As a result of the discussion of scientific articles, eleven journals discuss TPaCK competencies as 21st-century teacher skills and the role of mobile learning in improving 21st-century technology competencies. This study examines eleven journals that discuss TPaCK competencies as 21st-century teacher skills and the role of mobile learning in improving technological competencies. In the planning stage, articles were collected from Google Scholar and Research Rabbit using the keywords “Competency in TPaCK”, “21st Century Learning”, and “Mobile Learning”, and focused on articles published in the last five years to ensure the data was relevant and up-to-date.

In the implementation phase, quality assessment was conducted on journals published on Open Journal Systems (OJS) by reading titles and abstracts to ensure relevance and quality. Eleven journals were selected based on the topics of the TPaCK framework in 21st-century learning and Mobile Learning to improve technological competence. The results showed that the application of TPaCK and Mobile Learning can improve teachers' competence in integrating technology into teaching. Emphasized the importance of mastering TPaCK and using the Merdeka Teaching Platform to adapt to technological developments (Cholilah et al., 2023; Hamsia et al., 2022). Sari & Priatna (2020) found that Mobile Learning increased learning flexibility and interactivity, while Hakiki et al., (2022) reported that Mobile Learning training improved teachers' ability to develop technology-based learning media. Hasjiandito et al., (2023) and Akbar & Djakaria (2023) showed that training and using Android-based applications can improve teachers' technological competence and confidence. This research shows that Mobile Learning is effective in improving teachers' TPaCK competencies, helping them integrate technology into teaching, and adjusting to 21st-century learning needs. This supports the conclusion that technology and pedagogy must be continuously developed to improve the quality of education.

Table 1. Research Study of Previous Literature

No.	Author/Year	Title	Journal	Purpose	Method
1	Veronica et al., (2023)	Penguasaan TPACK & Kemampuan Abad 21 Bagi Guru Sekolah Dasar dalam Perspektif Kurikulum Merdeka	Prosiding Seminar Nasional Pagelaran Pendidikan Dasar Nasional (PPDN)	The Importance of Professional Elementary School Teachers having Mastery of TPACK and Modern Skills from an Independent Curriculum Perspective	Metode Systematic Literature Review

No.	Author/Year	Title	Journal	Purpose	Method
2	Tambak et al., (2023)	Penguatan Kompetensi Technological,Pedagogical Content Knowledge Guru Madrasah Tsanawiyah Melalui Pelatihan Pembelajaran. Berbasis Etnopedagogi	SAJAK	To DEVELOP the Competence of Technological Pedagogical Content Knowledge of Private Madrasah Tsanawiyah Teachers in Dumai City.	Metode Participation Action Research.
3	Akbar & Djakaria (2023)	Pemanfaatan Media Pembelajaran Berbasis Android: Menggunakan Pendekatan inkuiri untuk Menguatkan, Technological, Pedagogical and Content Knowledge (TPACK) Calon Guru	Oxygenius: Journal Of Chemistry Education	To Get an Illustration of the Utilization of Android-based Learning Media, an Inquiry Approach is Used to Improve Prospective Teachers' Educational Technology and Content Knowledge (TPACK).	Metode Library Research
4	Cholilah et al., (2023)	Pengembangan Kurikulum Merdeka, dalam Satuan Pendidikan Serta Implementasi Kurikulum Merdeka Pada Pembelajaran Abad 21	Sanskara Pendidikan dan Pengajaran	To Determine how Similar and Suitable these Two Stages of Development are to the Principles of Educational Technology and the Application of Merdeka Curriculum in 21st Century Education.	Descriptive Qualitative Method
5	Sari & Priatna (2020)	Model Model Pembelajaran di Era Revolusi Industri 4.0 (E-learning, M-learning, AR-Learning dan VR-learning)	Biormatika : Jurnal ilmiah fakultas keguruan dan ilmu pendidikan	Outline learning Models that can be Used to Deal with the Industrial Revolution 4.0 in Indonesian Education.	Metode Systematic Literature Review
6	Rahmi et al., (2020)	Pelatihan E-learning untuk Mengintegrasikan TIK dalam Pembelajaran bagi Guru-guru SMA	Jurnal Panrita Abdi	Provide Training to SMA N 4 Pariaman Teachers on how to Create E-learning and how to Use ICT in the Learning Process.	Method of Implementation
7	Hasjiandito et al., (2023)	Pengembangan Aplikasi Berbasis Android Sebagai Upaya Peningkatan	Jurnal Penelitian dan Pengabdian Kepada Masyarakat UNSIQ	Improving PAUD Teachers' Cognitive and TPACK Skills through Android Application	Method of Implementation

No.	Author/Year	Title	Journal	Purpose	Method
		Kompetensi TPACK Guru PAUD		Development Training Activities.	
8	Hakiki et al., (2022)	Pelatihan Media Pembelajaran Berbasis Mobile Learning Menggunakan Aplikasi, Goole Sites di SMK Negeri 4 Bungo	Jurnal Pengabdian Pendidikan Masyarakat (JPPM)	To Help Teachers Optimize and Utilize 'Mobile Learning' based Learning Media during the Learning Process.	Implementation methods with lectures, demonstrations, practice/training, and design
9	Hikmah et al., (2023)	Pelatihan Pembuatan Perangkat Pembelajaran Berbasis TPACK bagi Guru-Guru Madrasah Al-Aziziyah Gunungsari	Rengganis Jurnal Pengabdian Masyarakat	To Improve the Professionalism of Educators, Especially in Terms of Technology-based Learning Media Design.	Implementation method through lectures, discussions, and questions and answers
10	Rosmaladewi et al., (2023)	Mastering Of Technological Content Knowledge (TPACK Of Prospective Teaching Students In Supporting Digital Learning	KOLOKIUM: Jurnal Pendidikan Luar Sekolah	To Explain how Important TPACK Mastery is for Students who will Become Teachers for their Readiness in Digital Learning	Metode Systematic Literature Review
11	Perdani & Andayani (2021)	Pengaruh Kemampuan: Technological Pedagogical Content Knowledge (TPACK) Terhadap Kesiapan Menjadi Guru	Jurnal Pendidikan Akuntansi Indonesia	To Explore how Technological Pedagogical Content Knowledge (TPACK) Affects Students' Readiness to Become Teachers	Explanatory Quantitative Method

RQ1: Framework of TPaCK Competencies as 21st-Century Teacher Competencies

Technological, Pedagogical, Content Knowledge (TPaCK) competency is the right framework as a 21st-century teacher competency. Integrating technology in teaching (pedagogy) and delivering material (content) by teachers becomes a complete framework and becomes a unified option that teachers can master in the 21st century (Koehler & Mishra, 2009). TPACK (Technological Pedagogical and Content Knowledge) is the knowledge a teacher has about technology, pedagogy, and learning content and how they work together. This concept divides TPACK into seven components, namely technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), content technological knowledge (TCK), pedagogical technological knowledge (TPK), and content pedagogical technological knowledge (TPACK) (Hasjiandito et al., 2023).

In research by Veronica et al., (2023) it is revealed that mastery of competencies in the perspective of 21st-century learning, namely education today is not only sourced from books, but can be obtained from various sources both from digital platforms, the environment, and other sources. This phenomenon is in line with the Merdeka Curriculum used in Indonesia. Therefore, the role of teachers who are technologically literate and have adequate soft skills is indispensable.

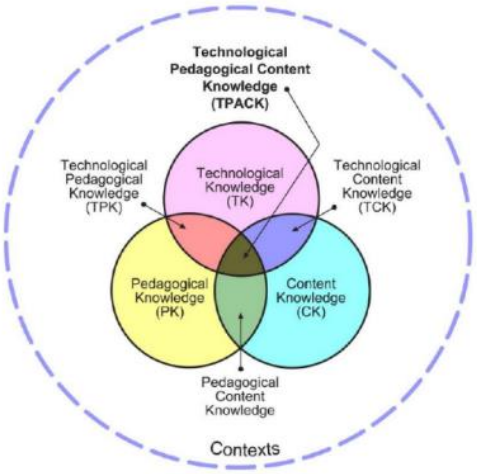

Figure 1. Framework TPACK (Koehler & Mishra, 2009)

This responds to the question of TPaCK competency as a 21st-century teacher competency. Teachers must be able to master 21st-century skills (mastery of 4C; creative thinking, critical thinking and problem-solving, communication, and collaboration), through the HOTS approach, and TPACK so that they can be implemented in learning. This mastery is expected to create creativity and innovation in education that can meet and accommodate the needs and characteristics of students (Veronica et al., 2023).

Research by Cholilah et al., (2023) revealed that to accelerate the development of an independent curriculum in educational institutions, there are several things that need to be considered. One of them is optimizing the Independent Teaching Platform (PMM). In addition, this will impact achieving learning objectives effectively and efficiently. The people involved, including teachers, school staff, learners, and parents, always need socialization, both online and offline. This is given the need for educators to adjust to the times.

Cholilah et al., (2023) also mentioned that there is a role of Educational Technology in designing learning in the 21st century, which if summarized from several previous researchers can be known according to: (1) Michael Molenda - Instructional Technology or Instructional Technology, which includes the design, development, use, and evaluation of technology in the learning process. (2). Seels & Richey - Educational Technology, which includes the utilization of resources, processes, and technological principles to improve the effectiveness of the learning process. (3). Januszewski & Molenda - Learning Technologies, which includes using technology to support, enhance, and facilitate the learning process of learners. (4). David H. Jonassen - Cognitive Tools, which covers the development and use of technology to help learners construct knowledge and effectively solve problems.

So the authors know that in terms of improving the competence of 21st-century teachers with mobile-based learning, the role of Educational Technologists through their area is also needed. Educators who have high TPACK competence will be more confident in the design of lesson plans, methods, strategies, and the use of digital learning media. They must also be able to adapt TPACK to the rapid development of the times and use technology in various areas of TPACK dominance in learning, from content preparation to assessment analysis preparation (Rosmaladewi et al., 2023).

RQ2: Mobile Learning Process in Formal Schools

Research by Sari & Priatna (2020) explains that mobile-based learning or Mobile Learning in the 21st century has been frequently used. M-learning, also known as mobile learning, refers to the use of information technology devices such as cell phones, mobile phones, laptops, and laptops. In this context, we concentrate on mobile phone devices. One of the goals of Mobile Learning development is long-life learning.

Mobile Learning is a learning concept that uses information and communication technology. According to this learning idea, Mobile Learning has advantages such as teaching materials that can

be accessed at any time and attractive visualizations for the material (Sari & Priatna, 2020). The ASSURE model is a framework used to effectively plan and implement technology-based learning, which is particularly relevant in the context of the Industrial Revolution 4.0. The first step is to analyze the characteristics and needs of learners, who are now digital natives accustomed to technology. Next, learning objectives are set with specific and measurable, including improving digital literacy and the ability to use technology (Dikmen & Demirer, 2022). In selecting methods, media, and materials, the ASSURE model encourages the use of E-Learning, M-Learning, AR-Learning, and VR-Learning, which are proven to increase learner interest and engagement. Educators should prepare and use these media and materials effectively during the learning process. The ASSURE model also calls for active learner participation through online discussions, collaborative assignments, and interactive learning applications, and provides constructive feedback. Continuous evaluation and revision is done to improve the quality of learning. The implementation of the ASSURE model utilizes technology to enhance interaction between learners and educators, provide unlimited learning resources, and improve learning effectiveness, ensuring that technology is used optimally to support the teaching and learning process and achieve expected learning outcomes. So it can be known that mobile-based learning can take place by integrating technological competencies into it so that the material can be provided with a delivery strategy for teaching (pedagogy). And this is included in the concept of TPaCK thinking.

RQ3: The Role of Mobile Learning in Improving Teachers' 21st-Century Technological Competencies

Table 2. Experimental Results of M-Learning on TPaCK

No.	Indicator	Before (%)	After (%)
1	Technological Knowledge	83.61	89.30
2	Pedagogical Knowledge	83.71	89.64
3	Content Knowledge	88.42	89.94
4	Technological Content Knowledge	83.49	89.22
5	Pedagogical Content Knowledge	86.14	89.64
6	Technological Pedagogical Knowledge	82.95	88.73
7	Technological Pedagogical Content Knowledge	83.66	89.16
Mean		**84.57**	**89.16**

From several utilizations of mobile as a tool for the learning process, the author found several studies related to the actualization of Mobile Learning. Hasjiandito et al., (2023) research said the Development of Android-based applications as an Effort to Improve Tpack Competencies for Paud Teachers: The results showed that the teacher's understanding of TPACK before the service activity was 84.57%, and after processing the training material the teacher's understanding became 89.16%. Android application development is carried out using smart application developer software, which is a computer application used to create various kinds of learning media or something similar to that. Then the research from Hakiki et al., (2022) is the increasing ability of SMK Negeri 4 Bungo teachers to develop online learning media, as shown by the results of making cellphone-based learning media using the Google Sites application, where each PKM participant has relevant subjects. In addition, the increased confidence of SMK Negeri 4 Bungo teachers in incorporating technology into digital learning services.

The implementation of Mobile Learning allows teachers to develop various mobile-based learning media, which improves their ability to use technology for teaching. Teachers become more skilled in designing teaching materials and delivering materials using mobile devices (Bueno et al., 2023). In line with this Rossi & Trevisan (2018) mentioned in their findings that the implementation of Mobile Learning allows teachers to develop a variety of mobile-based learning media, which improves their ability to use technology to teach.

The same thing was also found in Akbar & Djakaria (2023) to strengthen previous research using android, namely by using an inquiry approach to improve pedagogical and content technology knowledge (TPACK) of prospective teachers, it has been found that the results of using Android-based learning media with an inquiry approach can improve pedagogical and content technology knowledge (TPACK) of prospective teachers. This is because this approach can train prospective

teachers, build confidence, and give them the confidence to integrate technological knowledge with content knowledge (Koehler et al., 2013; Mishra & Koehler, 2006).

Rahmi et al., (2020) research where E-Learning Training to Integrate ICT in High School Teachers' Learning produced results that teachers have successfully created a complete e-learning material package for one meeting, which covers all subjects in class X SMA. This material package consists of various types of e-learning content, including text, images, and videos, which can be accessed by students through their respective accounts. With this training, teachers become ready to import ICT into their learning. Research by Bahroni et al., (2019) which resulted in research that almost all teachers on average can operate well without many obstacles Using the saktibuider.com android application which means that teachers can integrate technology in designing subject matter (TCK) through mobile-assisted applications.

Then the research of Tambak et al., (2023) through Strengthening Competence: Technological Pedagogical Content Knowledge of Teachers in Madrasah Tsanawiyah with Learning Training with Ethnopedagogy found the results of android-assisted learning with a local cultural approach, madrasah tsanawiyah teachers can design and create video learning media by adjusting to the elements of video media. At this stage there are five stages designed and developed by madrasah teachers in making video learning media, so the results of this study concluded that the competence of technological pedagogy content knowledge (TPaCK) of teachers in madrasah tsanawiyah can develop through training designed with Ethno pedagogy-based learning materials.

From several studies above, it can be understood that many strategies and methods can be applied and developed by teachers using the Mobile Learning model, where mobile-based learning is very broad and has many technologies. So that the author can conclude that 21st-century learning requires teachers who have TPaCK (Technological Pedagogical Content Knowlege) competencies as 21st-century teacher competencies that must continue to be developed through various applications of methods so that teachers are ready to integrate ICT technology into digital learning to adapt the needs of students according to the demands of the times, which in this time the independent learning curriculum.

Discussion

The results of this study show that the application of TPaCK and Mobile Learning can significantly improve 21st-century teachers' competencies in integrating technology into teaching. This finding is consistent with the TPaCK theory that emphasizes the importance of simultaneous technological, pedagogical, and content knowledge. For example, Veronica et al., (2023) argued that mastery of TPaCK is essential for creating effective and meaningful learning, while Sari & Priatna (2020) also found that Mobile Learning enhances learning flexibility and interactivity. This research is consistent with the results of previous studies. Hasjiandito et al., (2023) showed that Mobile Learning training improved teachers' understanding of TPaCK, and Hakiki et al., (2022) found that the training improved teachers' ability to develop technology-based learning media. Akbar & Djakaria (2023) also reported that the use of Android-based applications and an inquiry approach improved prospective teachers' confidence and technological competence.

The main difference between this study and previous studies is the focus on the application of Mobile Learning as the main approach to improving teachers' TPaCK competencies in Indonesia. This study uses the Systematic Literature Review (SLR) method with the PRISMA framework, which allows for a more comprehensive and systematic analysis compared to other studies using different methods. However, this study has several limitations. First, it only reviewed eleven journals published in the last five years, so it may not cover all relevant literature. Secondly, the focus of this study is limited to the Indonesian education context, so the results may not be fully applicable in other contexts. The implication of these limitations is the need for further research covering more literature and a wider context to strengthen these findings. In addition, more in-depth field research is needed to test the effectiveness of mobile learning in various educational settings.

The findings are important for policymakers in designing digital technology-based teacher competency improvement strategies, providing empirical evidence supporting the adoption of Mobile Learning as an effective method. This research made an important contribution to educational

practice by showing that Mobile Learning can be an effective tool to improve teachers' TPaCK competencies. Educators and policymakers can use these findings to design training programs that are more effective and relevant to 21st-century needs. For future research, there are opportunities to further explore how different types of mobile technologies can be used to support learning in various educational contexts. Research could also focus on developing learning models that combine TPaCK with new and evolving technologies, as well as examining the long-term impact of implementing mobile learning on the quality of education.

CONCLUSION

From the discussion, it can be concluded: 1). The competencies of 21st-century teachers are TPaCK competencies. Where TPaCK competence is by the competencies of teachers in teaching and mastering material and integrating and actualizing technology into the teaching and learning process. 2). TPaCK competency is a framework of combining Technological Pedagogical Content Knowledge. The framework can be described as TK (Technological Knowledge), PK (Pedagogical Knowledge), CK (Content Knowledge), TCK (Technological Content Knowledge), PCK (Pedagogical Content Knowledge), TPK (Technological Pedagogical Knowledge), and TPaCK (Technological Pedagogical Content Knowledge). 3). Mobile-based learning, also known as Mobile Learning, can be used as a learning model that can improve teachers' TPaCK ability to adapt to 21st-century learning in the era of independent learning curriculum. By developing, implementing, and using mobile devices, teachers can improve their ICT skills in the design and use of synchronous and asynchronous learning. 4). The role of Educational Technologists through the areas of design, development, utilization, management, and assessment/evaluation is also needed as a 'friend' of teachers in improving performance and facilitating learning so that teachers do not feel difficult alone in developing 21st-century competencies because educational technologists are present with their role.

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