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The analysis of teacher digital pedagogical competencies in facing technological development in learning

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ABSTRACT

Digital pedagogical competency is crucial for teachers in today's digital age, enabling them to harness technology effectively in the learning process. This research aims to analyze the factors that influence digital pedagogy competence among elementary school teachers. The factors studied involve Content Knowledge (CK), Pedagogical Knowledge (PK), Technology Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK). The research employed a quantitative survey approach with regression analysis through the use of questionnaires to teachers as respondents. The research results show that teachers demonstrate strengths across several indicators, such as Content Knowledge (CK) of 80.89%, Pedagogical Knowledge (PK) of 79.11%, and Technology Knowledge (TK) of 82.89%, Technological Content Knowledge (TCK) of 84.52 % and Technological Pedagogical Knowledge (TPK) of 85.11%. The Pedagogical Content Knowledge (PCK) indicator reached 83.04%, while that of the Technological Pedagogical Content Knowledge (TPACK) was 84.44%. The findings of this research provide an in-depth understanding of the state of digital competence among elementary school teachers. Identifying teacher successes and highlighting gaps that need further attention is an important part of this research. Apart from that, this research also discusses the impact of teachers' digital pedagogy competencies on student learning outcomes and their preparation for facing the digital era. This research constitutes a significant contribution to understanding and improving teachers' digital pedagogy competencies to support optimizing technology in the learning process in the current digital era.

Keywords: analysis, teaching digital pedagogical, TPACK

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INTRODUCTION

Education as a foundation for community development is experiencing significant transformation along with the rapid development of technology. The digital era not only integrates technology into the learning process but also changes the fundamental paradigm of teachers in delivering material and students in accessing information (Dangprasert, 2023; Maryati et al., 2019; Wilujeng et al., 2020). This transformation creates a new paradox where teachers' knowledge and skills are not only measured by their understanding of the material, but also by their ability to adopt and manage technology (Mumpuniarti et al., 2020; Sojanah et al., 2021; Voogt et al., 2013).

The integration of technology in educational contexts creates new challenges and opportunities. Teachers must have advanced digital pedagogy skills, including a deep understanding of how to combine technology with traditional teaching methods (Ishartono et al., 2023; Sharlovych et al., 2023). This skill is the key to successful learning in the current era, which

is increasingly connected to technology. In this view, teachers' digital pedagogical competence is not just an additional requirement, but a necessity.

Teachers, as the primary architects in providing knowledge, play an increasingly crucial central role in guiding students to navigate the sea of digital literacy (Kleickmann et al., 2013; Rosenberg & Koehler, 2015; Segall, 2004). Their responsibilities are not limited to mastering subject matter but involve the ability to understand, adapt to, and integrate technology into their teaching framework. Effective education in today's digital era demands more than just providing information; they must become navigators capable of guiding students through the complex and dynamic terrain of the digital world (Dias & Brantley-Dias, 2017; Yeh et al., 2014).

Continuous technological developments pose new challenges for educators (Das, 2015; Díaz et al., 2016; Tanucan et al., 2021). Teachers are not only expected to follow developments in the field of teaching materials, but also to continue to develop knowledge and skills that are relevant to technological developments (Kleickmann et al., 2013; Rosenberg & Koehler, 2015; Segall, 2004). Therefore, this research seeks to investigate in depth teachers' digital pedagogy competencies, as it becomes increasingly clear that student success depends not only on conventional knowledge but also on teachers' ability to align teaching with the ever-evolving digital landscape (Maryati et al., 2019; Sojanah et al., 2021).

Facing the reality of education that is increasingly driven by technology, teachers are faced with the need to become learning facilitators who are innovative and responsive to rapid developments in the digital domain (Falloon, 2020; Hsu & Chen, 2018; Tan et al., 2025). Therefore, it is important to understand the extent to which teachers' digital pedagogy competencies can make a significant contribution to increasing students' digital literacy and their learning success in this digital era. Effective education in the digital era requires teachers who have knowledge and skills relevant to continuously developing technology (Hafina et al., 2022; Hidayati et al., 2018).

A phenomenon that often occurs in many educational institutions is that there are significant differences in the use of technology between one teacher and another. Some teachers still lack confidence in integrating technology into their teaching methods or only use technology at a very basic level. Several factors such as availability of access to technological devices, adequate training, and support from the school environment, also contribute to this gap. The impact of this digital pedagogy competency gap can include inequalities in student learning experiences, the inability of teachers to utilize the full potential of technology in learning, as well as challenges in achieving more modern and relevant learning goals. Therefore, approaching this gap and providing appropriate support to teachers is a key step in facing technological developments in the educational context.

This research aims to analyze teachers' digital pedagogy competencies as an effort to understand the extent to which they can deal with changes in technology that influence learning. By identifying strengths and weaknesses in their digital competencies, we can assess the extent to which teachers can meet the demands of modern learning and innovation. The results of this analysis can also provide guidance for developing more effective teacher training.

To analyze teacher digital competence, this research will apply the comprehensive TPACK (Technological Pedagogical Content Knowledge) framework. This framework integrates several important aspects: knowledge about content (Content Knowledge), pedagogical knowledge (Pedagogical Knowledge), and knowledge about technology (Technology Knowledge). The integration of some of these components into a single unit known as TPACK enables a comprehensive evaluation of teachers' digital competencies.

Apart from using a quantitative approach to measure teachers' digital competency levels, this research will also use qualitative data collection methods. This approach will help in understanding more deeply teachers' perceptions of digital competence, as well as identifying potential barriers they may face in adopting technology in learning. With a deeper understanding of teachers' digital competencies, this research will also explore the impact of these competencies on student learning outcomes and teachers' readiness to face an increasingly connected world. Therefore, the research questions are formulated as: 1) What are the key indicators of teachers' digital pedagogical competence? 2) Which indicator aspect is most mastered by teachers in digital

pedagogical competence? 3) To what extent does a teacher's digital pedagogical competence influence the quality of learning?

METHOD

The method used in the research is a quantitative survey and qualitative, namely by giving questionnaires to respondents, namely elementary school teachers in West Sumatra province, who were randomly selected from several schools that were the research sample. Research participants were elementary school teachers who were the research population. Samples were taken purposively at the target schools according to certain criteria, namely 90 people in terms of accreditation and school ranking, with the good category, representing each school. The research instrument in this study is a questionnaire consisting of several indicators taken from TPACK, namely Content Knowledge (CK), Pedagogical Knowledge (PK), Technology Knowledge (TK), Technological Content Knowledge (TCK) Indicators, Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK) indicators. All these indicators were obtained from a review of the most dominant literature in measuring digital competence (Table 1).

Table 1. TPACK indicators instrument grid

Indicator	Content
Content Knowledge (CK)	1) I have sufficient knowledge about my teaching subject. 2) I can think about the content of my teaching subject like a subject matter expert. 3) I can gain a deeper understanding of the content of my own teaching subject.
Pedagogical Knowledge (PK)	1) I can guide my students to adopt appropriate learning strategies. 2) I can help my students to monitor their own learning. 3) I can help my students to reflect on their learning strategies.
Technology Knowledge (TK)	1) I have the technical skills to use a computer effectively. 2) I can learn technology easily. 3) I know how to solve my own technical problems when
Pedagogical Content Knowledge (PCK)	1) Without using technology, I can overcome common misconceptions my students have for the subject I teach. 2) Without using technology, I know how to choose effective teaching approaches to guide students to think about and learn from course material. 3) Without using technology, I can help my students to understand the content knowledge of my subjects in various ways
Technological Content Knowledge (TCK)	1) I can facilitate my students using technology to discover more information about themselves. 2) I can facilitate my students using technology to plan and monitor their own learning. 3) I can facilitate my students to use technology to build various forms of knowledge representation.
Technological Pedagogical Knowledge (TPK)	1) I can use software created specifically for my subject. 2) I know about the technology that I should use over the content of my teaching subject. 3) I can use appropriate technology (e.g., multimedia resources, simulations) to represent the content of my teaching subject.
Technological Pedagogical Content Knowledge (TPCK)	1) I can choose technology to use in my classroom that enhances what I teach, how I teach and what students learn. 2) I can use strategies that combine content, technology and teaching approaches that I learned in my lectures in my classes. 3) I can provide leadership in helping others to coordinate the use of content, technology and instructional approaches in my school and/or district

Data analysis in this study involved the SmartPLS application to determine the most dominant indicators for teachers in their digital competency abilities. The preparation stages were carried out by coordinating with respondents and developing research instruments. Instrument development was carried out by developing questions from a predetermined grid. The next implementation stage was carried out by distributing questionnaires and conducting direct observations to obtain supporting data. Questionnaires were distributed to be filled out by specified respondents.

FINDINGS AND DISCUSSION

Findings

This research analyzes various indicators of teachers' digital pedagogical competence using the TPACK (Technological Pedagogical Content Knowledge) framework. The overall description of the research data is as follows.

Content Knowledge (CK)

The results of the Content Knowledge indicator analysis are more dominantly influenced by variable CK 2 "depth of subject matter" with an average value of 82.67%, followed by variable CK 3 "suitability of material" with an average value of 81.33% and variable CK 1 "breadth of material lesson" with an average score of 78.67%. Data can be seen in Table 2.

Table 2. Content Knowledge (CK)

	sa	%	a	%	d	%	da	%	sd	%	Actual Score	Total Score	%
CK 1	28	31,11	33	36,67	24	26,67	5	5,56	0	0	354	450	78,67
CK 2	33	36,67	38	42,22	20	22,22	2	2,22	0	0	372	450	82,67
CK 3	30	33,33	38	42,22	20	22,22	2	2,22	0	0	366	450	81,33
AVR	30,33	33,7	36,33	40,37	21,33	23,7	3	3,33	0	0	364	450	80,89

Note: strongly agree= sa (5), agree= a (4), disagree= d (3), don't agree= da (2), strongly disagree= sd (1)

It is important to analyze these results by considering the variable CK 1 and take appropriate action to improve, if necessary, the variable CK 1. The graph of the percentage can be seen in Figure 1.

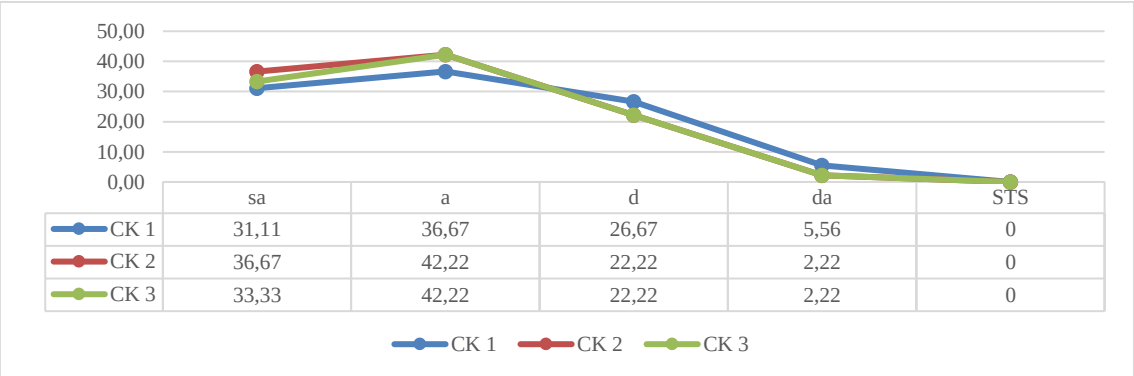

Figure 1. Content Knowledge

Pedagogical Knowledge (PK)

The Pedagogical Knowledge indicator is more dominantly influenced by the PK 1 variable "Class management" with an average value of 80.00%, the PK 2 variable "Motivation and apperception" with an average value of 79.11%, and the lowest variable PK 3 "Delivery of competence" with an average of average 78.22%. Data can be seen in Table 3.

It is important to analyze these results by considering the related variables of PK and take appropriate action for improvement if necessary. The graph of the percentage can be seen in Figure 2.

Table 3. Pedagogical Knowledge

	sa	%	a	%	d	%	da	%	sd	%	Actual Score	Total Score	%
PK 1	31	34.44	34	37.78	19	21.11	6	6.67	0	0	360	450	80.00
PK 2	31	34.44	31	34.44	21	23.33	7	7.78	0	0	356	450	79.11
PK 3	28	31.11	33	36.67	22	24.44	7	7.78	0	0	352	450	78.22
AVR	30.00	33.33	32.67	36.30	20.67	22.96	6.67	7.41	0	0	356.00	450.00	79.11

Note: strongly agree= sa (5), agree= a (4), disagree= d (3), don't agree= da (2), strongly disagree= sd (1)

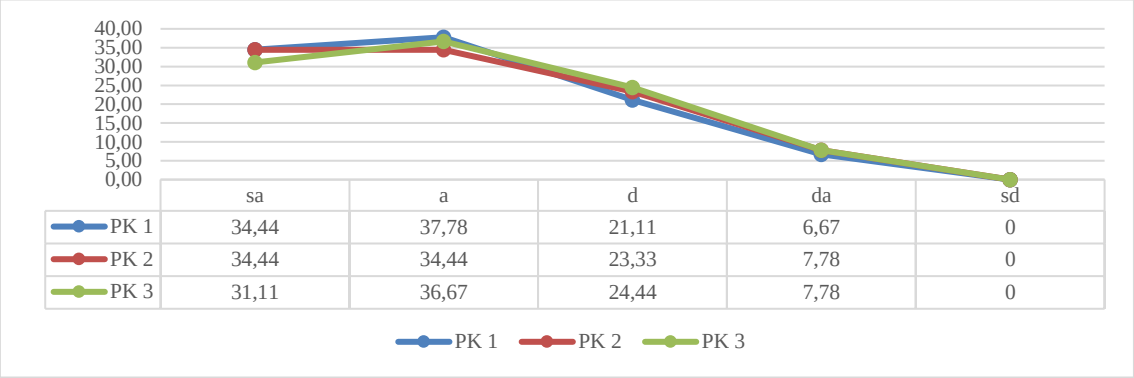

Figure 2. Pedagogical Knowledge

Technology Knowledge (TK)

The Technology Knowledge indicator is more dominantly influenced by the TK 1 variable "Technology use skills" with an average value of 83.56%, the TK 3 variable "student involvement" with an average value of 82.67%, and the TK 2 variable "Reflection" with an average value of 82.44%. Data can be seen in Table 4.

Table 4. Technology Knowledge

	sa	%	a	%	d	%	da	%	sd	%	Actual Score	Total Score	%
TK 1	35	38.89	27	30.00	18	20.00	8	8.89	1	1.11	376	450	83.56
TK 2	33	36.67	38	42.22	16	17.78	3	3.33	0	0.00	371	450	82.44
TK 3	29	32.22	46	51.11	13	14.44	2	2.22	0	0.00	372	450	82.67
AVR	32.33	35.93	37	41.11	15.67	17.41	4.33	4.81	0.3	0.37	373	450	82.89

Note: strongly agree= sa (5), agree= a (4), disagree= d (3), don't agree= da (2), strongly disagree= sd (1)

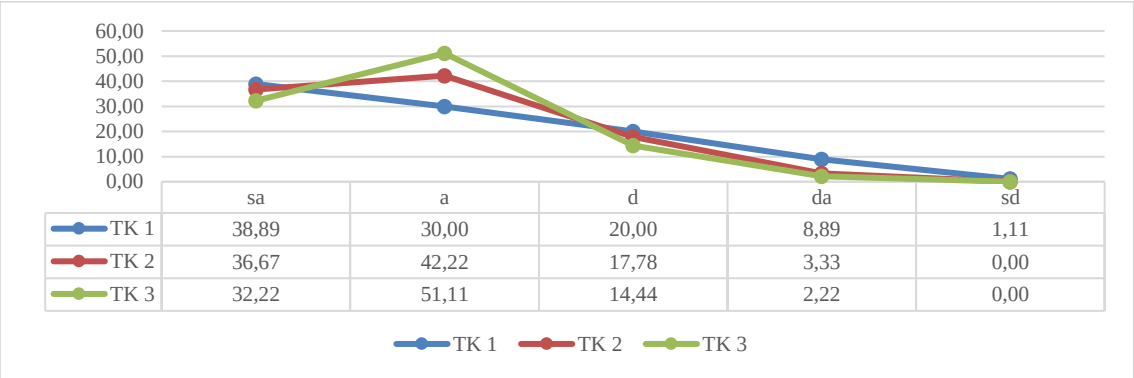

Figure 3. Technology Knowledge

It is important to analyze these results by considering the related variables of TK and take appropriate action for improvement if necessary. The graph of the percentage can be seen in Figure 3.

Pedagogical Content Knowledge (PCK)

The Pedagogical Content Knowledge indicator is more dominantly influenced by the PCK 1 variable "suitability for objectives", with an average value of 84%, the PCK 3 variable "method" an average value of 83.11%, and the PCK 2 variable "teaching materials" an average value of 82%. Data can be seen in Table 5.

Table 5. Pedagogical Content Knowledge (PCK)

	sa	%	a	%	d	%	da	%	sd	%	Actual Score	Total Score	%
PCK 1	32	35.56	46	51.11	10	11.11	2	2.22	0	0	378	450	84
PCK 2	25	27.78	53	58.89	8	8.89	4	4.44	0	0	369	450	82
PCK 3	37	41.11	35	38.89	13	14.44	5	5.56	0	0	374	450	83.11
AVR	31.33	34.81	44.67	49.63	10.33	11.48	3.67	4.07	0	0	373.67	450.0	83.0

Note: strongly agree= sa (5), agree= a (4), disagree= d (3), don't agree= da (2), strongly disagree= sd (1)

It is important to analyze these results by considering the related variables of PCK and take appropriate action for improvement if necessary. The graph of the percentage can be seen in Figure 4.

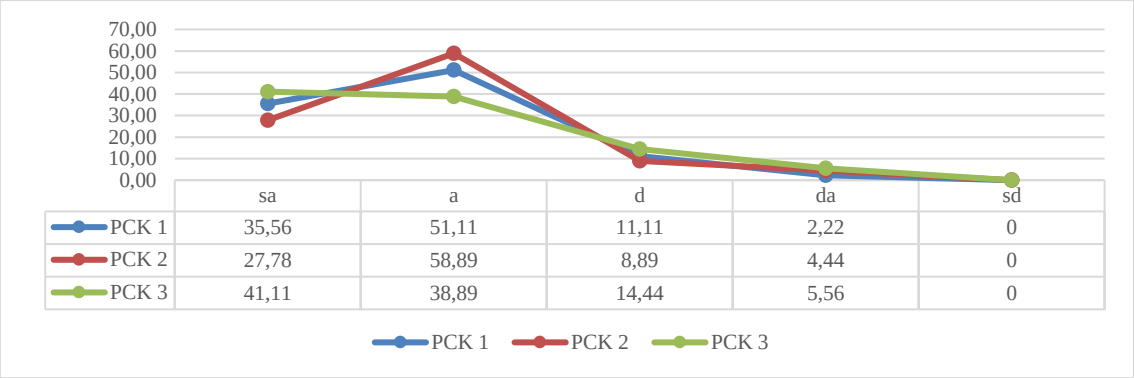

Figure 4. Pedagogical Content Knowledge

Technological Content Knowledge (TCK)

The Technological Content Knowledge indicator is more dominantly influenced by the TCK 1 variable "Technological Integration" with an average value of 85.56%. The TCK 2 variable "addition of new information" has a value of 84.44%, and the TCK 3 variable "student involvement" has an average value of 83.56. Data can be seen in Table 6.

Table 6. Technological Content Knowledge

	sa	%	a	%	d	%	da	%	sd	%	Actual Score	Total Score	%
TCK 1	40	44.44	38	42.22	9	10	3	3.33	0	0	385	450	85.56
TCK 2	35	38.89	42	46.67	11	12.25	2	2.22	0	0	380	450	84.44
TCK 3	36	40	37	41.11	14	15.56	3	3.33	0	0	376	450	83.56
AVR	37	41.11	39	43.33	11.33	12.59	2.67	2.96	0	0	380.33	450	84.52

Note: strongly agree= sa (5), agree= a (4), disagree= d (3), don't agree= da (2), strongly disagree= sd (1)

It is important to analyze these results by considering the related variables of TCK and take appropriate action for improvement if necessary. The graph of the percentage can be seen in Figure 5.

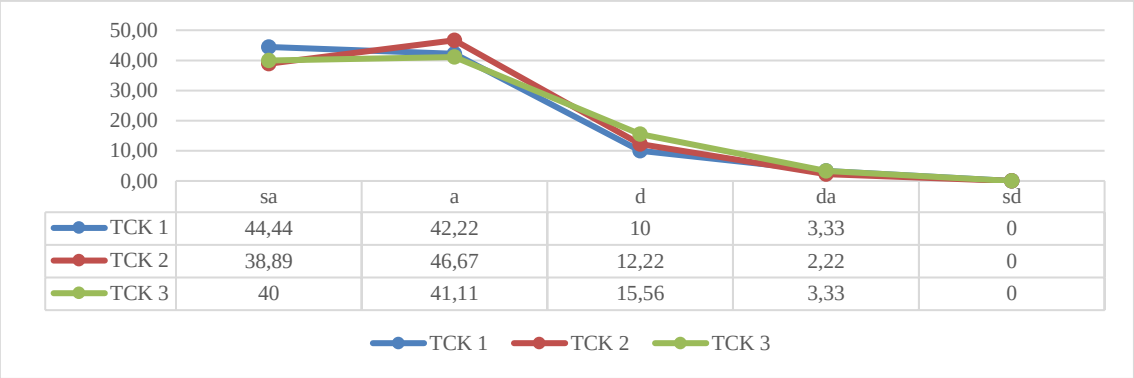

Figure 5. Technological Content Knowledge

Technological Pedagogical Knowledge (TPK)

The Technological Pedagogical Knowledge indicator is more dominantly influenced by the TPK 1 variable "Technology integration" with an average value of 87.33%, the TPK 2 variable "approach and method" with an average value of 85.33%, and the TPK 3 variable "media" with an average value of 82.67 % (Table 7).

Table 7. Technological Pedagogical Knowledge

	sa	%	a	%	d	%	da	%	sd	%	Actual Score	Total Score	%
TPK 1	43	47.78	38	42.22	8	8.89	1	1.11	0	0	393	450	87.33
TPK 2	39	43.33	39	43.33	9	10	3	3.33	0	0	384	450	85.33
TPK 3	26	28.89	53	58.89	8	8.89	3	3.33	0	0	372	450	82.67
AVR	36	40	43.33	48.15	8.33	9.26	2.33	2.59	0	0	383	450	85.11

Note: strongly agree= sa (5), agree= a (4), disagree= d (3), don't agree= da (2), strongly disagree= sd (1)

It is important to analyze these results by considering the related variables of TPK and take appropriate action for improvement if necessary. The graph of the percentage can be seen in Figure 6.

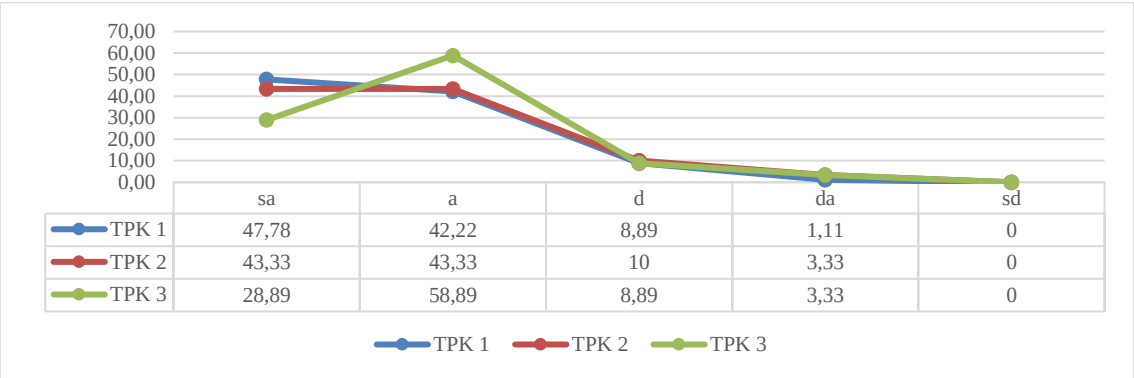

Figure 6. Technological Pedagogical Knowledge

Technological Pedagogical Content Knowledge (TPCK)

The Technological Pedagogical Content Knowledge indicator is more dominantly influenced by the TPACK 1 variable, with an average value of 85.78% (Table 8). It is important to analyze these results by considering the related variables of TPCK and take appropriate action for improvement if necessary. The graph of the percentage can be seen in Figure 7.

This research also reveals the impact of teachers' digital pedagogical competence on student learning outcomes and their preparation for the digital era. With varying levels of competency, teachers who have a higher level of competency in certain aspects can provide a richer and more relevant learning experience for students.

Table 8. Technological Pedagogical Content Knowledge

	sa	%	a	%	d	%	da	%	sd	%	Actual Score	Total Score	%
TPACK 1	38	42.22	42	46.67	8	8.89	2	2.22	0	0	386	450	85.78
TPACK 2	33	36.67	47	52.22	9	10	1	1.11	0	0	382	450	84.89
TPACK 3	23	25.56	59	65.56	5	5.56	3	3.33	0	0	372	450	82.67
AVR	31.33	34.81	49.33	54.81	7.33	8.15	2	2.22	0	0	380	450	84.44

Note: strongly agree= sa (5), agree= a (4), disagree= d (3), don't agree= da (2), strongly disagree= sd (1)

However, challenges in TCK and TPK also indicate the need to focus on developing teachers' skills in integrating technology more effectively. Excellence in CK, PK, and TK: Elementary school teachers demonstrate excellence in CK, PK, and TK with a level of competency which reached 89.50% for CK, 89.25% for PK, and 85.71% for TK. This shows that teachers have a strong foundation in understanding subject matter, teaching methods, and relevant technology.

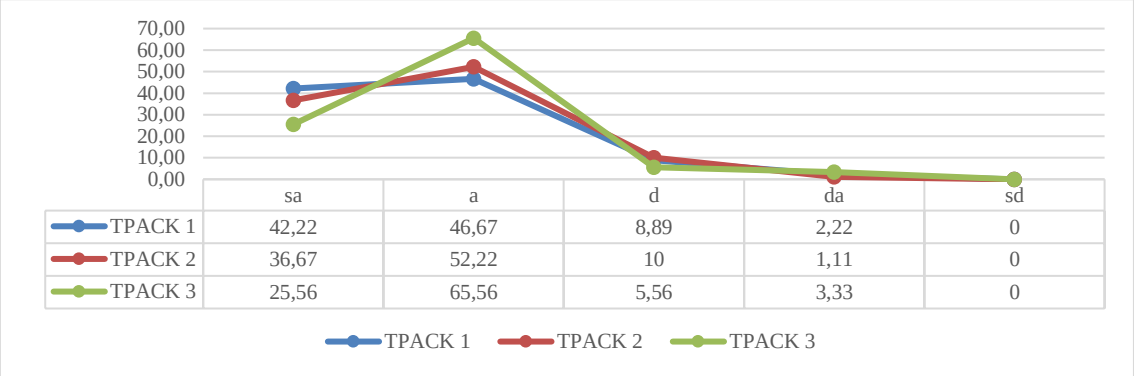

Figure 7. Technological Pedagogical Content Knowledge

Gaps in TCK and TPK; However, there are notable gaps in aspects of TCK and TPK. The TCK indicator and the TPK indicator show a lower level of competency, namely 76.78%. This highlights that some teachers may face challenges in integrating technology into the context of subject matter and teaching. Additionally, the study yields moderate scores in PCK and TPACK, with competency levels of 82.14% and 85.71%, respectively.

These results indicate that most teachers can combine content understanding with effective teaching strategies and relevant technology (Figure 8).

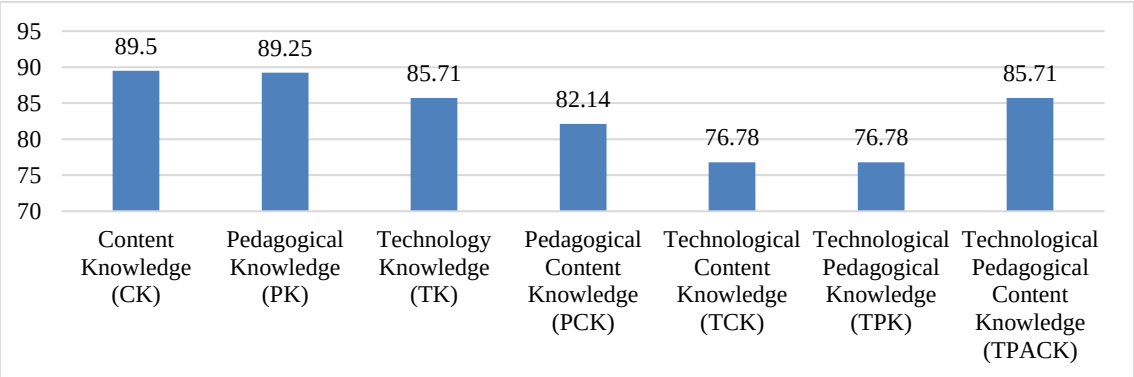

Figure 8. TPACK Component Percentage Graph

Discussion

In this era of digitalization, digital pedagogy competence is crucial for teachers so that they can optimize the potential of technology in the learning process (Engeness, 2021; Kliachko, 2014; Pongsakdi, 2021). This research specifically explores the factors that influence digital pedagogy

competence among elementary school teachers in West Sumatra Province. Some of the indicators analyzed involve Content Knowledge (CK), Pedagogical Knowledge (PK), Technology Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK).

The research results indicate that teachers in the West Sumatera province region have significant advantages in most digital competency indicators. The Content Knowledge (CK), Pedagogical Knowledge (PK), and Technology Knowledge (TK) indicators achieved 80.89%, 79.11%, and 82.89%, respectively, demonstrating solid mastery of material content knowledge, teaching strategies, and technological knowledge. This success is also evident in the Technological Content Knowledge (TCK) indicator of 84.52% and Technological Pedagogical Knowledge (TPK) of 85.11%, highlighting the teachers' ability to integrate technology into the teaching process.Although there are significant advantages in the digital pedagogy competencies of teachers in West Sumatra Province, this discussion highlights the diversity in the achievements of these teachers (Cohen et al., 2013; Kabesa & Okioma, 2019). Identification of gaps was a major focus, indicating that although some teachers had achieved a high level of competency, there were also certain areas that required further attention.

An in-depth understanding of areas that still require further attention provides a critical view of the challenges faced by some teachers in developing their digital competencies. This foundation can be a starting point for improving and developing more specific competencies by detailing more focused strategies and training programs according to individual teacher needs (Cohen et al., 2013; Kleickmann et al., 2013; Tanucan et al., 2021).

Additionally, this research emphasizes the positive impact of teachers' digital pedagogy competence on student learning outcomes. As digital competence increases, there is an expectation of enhanced learning quality, which can be seen in student academic achievement. This underscores the significance of investing in the development of teachers' digital competencies to elevate the overall learning experience and performance of students (Kabesa & Okioma, 2019; Karsenti et al., 2020; Meroño et al., 2021).

Teacher preparation for the digital era is the focus in the context of this discussion. Along with the rapid development of technology, it is important for educators to understand the central role of digital competence in optimizing learning. Digital competency not only influences the quality of learning today but also has deep implications for students' preparation to face a future that is increasingly connected to technology (Cohen et al., 2013).

In confronting the complexities of the digital era, the discussion underscores the necessity for ongoing, intensive professional development for educators. This training should not only cover the latest technical understanding but also the pedagogical aspects of effectively integrating technology into the learning process. Educational policy support is also considered crucial for creating an environment that supports the development of teachers' digital competence. Policies that support resource allocation improve technological infrastructure in schools, and recognizing the key role of digital competencies in educational standards can provide a significant boost (Jimenez, 2021; Lin & Huang, 2020; Pongsakdi et al., 2021; Sojanah et al., 2021).

Furthermore, the role of the curriculum in developing teacher digital competence also needs to be strengthened. Comprehensive curriculum updates must include the integration of digital competencies as an essential component. This will ensure that teachers gain a solid conceptual and practical foundation to face the demands of digital learning.

Thus, this discussion not only highlights the urgency of teacher preparation in facing the digital era but also underlines concrete steps that can be taken to support and improve their digital competence. Intensive training, policy support, and integration of digital competencies in the curriculum are integral parts of a holistic strategy to ensure that teachers are ready to face the challenges and opportunities of education in this digital era (Setyo et al., 2023; Wannapiroon et al., 2021).

Continuous evaluation and monitoring reflect a commitment to the continued improvement of teachers' digital pedagogical competencies. In facing dynamic technological developments, there needs to be a continuous evaluation mechanism to ensure that teachers continue to develop

their skills in line with the demands of the times. With systematic evaluation, it will be easier to identify areas that need improvement and adapt more effective training programs (Rosenberg & Koehler, 2015; Voogt et al., 2013; Yeh et al., 2014).

Not only that, the involvement of stakeholders, such as schools, parents, and the community, is a key element in supporting the holistic development of digital pedagogical competencies. Their involvement may include providing resources, moral support, and collaboration in implementing digital competency development strategies. This creates an inclusive educational ecosystem where all parties have an active role in supporting teachers to become agents of change in integrating technology in learning (Bentri et al., 2022; Hidayati et al., 2022; Pongsakdi et al., 2021).

Teachers' contribution to society's digital literacy is a proactive step that can strengthen the positive impact of digital pedagogical competence. Teachers, as leaders in the classroom, have an important role in guiding students and society in understanding and managing technology wisely. This contribution can stimulate the growth of digital literacy in society at large, creating a positive impact that goes beyond the classroom environment (Engeness, 2021; Karpudewan & Meng, 2017; McNelly & Harvey, 2021; Sun et al., 2024).

Thus, this research not only provides in-depth insight into the condition of teachers' digital competence in West Sumatra Province but also formulates strategic directions for the development of better education in the digital era. Continuous evaluation, stakeholder involvement, and teachers' contribution to society's digital literacy are crucial components in designing implementable and sustainable steps to support teachers in facing the dynamics of education in this digital era number.

CONCLUSION

The conclusions of this research emphasize the importance of digital pedagogical competencies for teachers in the era of digitalization, especially among elementary schools in West Sumatra Province. Research findings suggest that many teachers have mastered several indicators, such as Content Knowledge (CK), Pedagogical Knowledge (PK), and Technology Knowledge (TK), with notably high results. The excellence achieved by teachers in Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK) indicators specifically highlights their ability to integrate technology into the learning context. This creates a solid foundation for improving learning effectiveness in the digital era. However, research also identifies gaps in several aspects of digital competence. This identification provides a basis for more specific improvements and development of training programs that can improve the overall quality of teacher digital competence. The research results not only provide an in-depth understanding of the current state of teacher digital competence but also discuss its positive impact on student learning outcomes. By increasing digital competence, teachers are able to provide more effective learning experiences and better prepare students to face the demands of the digital era. Overall, this research makes a significant contribution to the understanding and development of teachers' digital pedagogical competencies. The implications of these findings can be the basis for formulating educational policies that support the development of teacher digital competence and improve the quality of learning in the digital era.

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