

Teacher Readiness for Implementing the Deep Learning Approach in Elementary School Education in the Society 5.0 Era

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Abstract

This study aims to analyze the readiness of elementary school teachers to implement deep learning in the Digital 5.0 era. The study used a mixed methods approach with a sequential explanatory design. The study subjects consisted of 364 elementary school teachers in Ponorogo Regency, Indonesia. The sample was selected using simple random sampling. Data were collected through questionnaires, interviews, observations, and documentation. Quantitative data were analyzed using descriptive statistics, while qualitative data were analyzed through source triangulation. The results showed that teacher readiness in implementing deep learning tended to be in the moderate category. Teachers' pedagogical and social competencies were in the moderate category, while their technological and professional competencies were in the high category. Supporting factors for deep learning implementation included support from school leaders, collaboration between teachers, teacher motivation to innovate, professional training, and the use of learning technology. Inhibiting factors included limited learning time, administrative burden, limited technological facilities, low digital literacy, and a lack of ongoing training. Triangulation results showed that teachers with high readiness were able to implement meaningful, mindful, and joyful learning through active learning methods and technology integration, while teachers with low readiness were still dominated by conventional learning. This study concludes that the implementation of deep learning in elementary schools requires systematic support through improving teacher competency, strengthening technological infrastructure, and educational policies that support 21st-century learning.

1. Introduction

The development of digital technology over the past two decades has created fundamental changes in various aspects of life, including education, which is now moving towards more dynamic, collaborative, and data-driven learning. This transformation did not occur instantly, but rather is the result of a long evolution triggered by the technological revolution since the industry 4.0 era, which includes process automation, the use of big data, the Internet of Things (IoT), and artificial intelligence (Fukuyama, 2018). According to Fonna (2019) explains that this phase is characterized by the penetration of digital technology into all dimensions of human life, including in how individuals learn, manage information, build social relationships, and interact in a digital-based ecosystem. Furthermore, Vittikh (2015) emphasized that the Society 5.0 Era is not merely a technical continuation of the Industrial Revolution 4.0, but a paradigm shift that places humans at the center of technology utilization. In this context, technology is no longer positioned as an external tool, but rather as an integral part of the human life ecosystem that is integrated into daily activities, including the learning process.

In the context of Indonesian national education, this transformation is further strengthened through the implementation of the Independent Curriculum which emphasizes differentiated learning and project-based learning and strengthening the profile of Pancasila Students. This curriculum encourages a paradigm shift in learning

from a teacher-centered approach to student-centered learning, where students play an active role in constructing knowledge through contextual and meaningful learning experiences (Mahrunnisya, 2023). This change implies that learning can no longer be understood as a linear process of knowledge transfer, but as a constructive process involving students' simultaneous cognitive, emotional, and social involvement. Therefore, teachers are required to be able to design learning experiences that are not only pedagogically effective but also relevant to the dynamics of technological developments and the needs of students in the Digital 5.0 era (Guo et al., 2020).

One learning approach that is conceptually relevant to these demands is Deep Learning from a pedagogical perspective, which emphasizes that the learning process is not only related to superficial mastery of content,

but also involves a process of deep, reflective, and continuous understanding (Mystakidis et al., 2019). According to Puskurjar (2025) explains that Deep Learning has three main dimensions, namely mindful, meaningful, and joyful. The mindful dimension emphasizes full awareness in learning, so that students deeply understand what is learned. The meaningful dimension emphasizes the relationship between concepts and relevance to real life, while the joyful dimension emphasizes the importance of enjoyable learning experiences to increase student engagement. These three dimensions are the foundation for developing higher-order thinking skills or Higher Order Thinking Skills (HOTS) which is still a challenge in the Indonesian education system.

However, the implementation of Deep Learning in learning practices cannot be separated from the readiness of teachers to integrate various aspects of learning simultaneously. In this case, the Technological Pedagogical Content Knowledge (TPACK) framework is very relevant to analyze teachers' integrative abilities. According to Assegaf et al., (2026) explains that TPACK includes the integration of Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK), as well as intersections between the three such as PCK, TCK, TPK, and TPACK. According to Hanik et al., (2022) emphasizes that mastery of TPACK allows teachers to utilize technology not only as a tool, but as part of a pedagogical strategy that supports meaningful learning. Therefore, teacher readiness in implementing Deep Learning must be viewed comprehensively through integrative abilities within the TPACK framework.

Although conceptually, TPACK integration is a key requirement in learning in the Digital 5.0 era, empirical conditions show that teacher readiness still faces various challenges (Akram et al., 2022). According to Dewi et al., (2025) stated that the main obstacle lies not in limited facilities, but in teachers' low digital literacy, limited experience in managing digital learning, and a lack of training focused on the integration of pedagogy, content, and technology. This condition is also found in semi-urban areas such as Ponorogo Regency, where there is variation in access and utilization of technology between schools (Muharam et al., 2025). In addition, Arifudin (2022) showed that learning practices are still dominated by conventional methods that do not support the development of higher-order thinking skills. According to Azizi SM et al. (2024) also emphasized that many teachers experience difficulties in integrating technology with learning strategies, while Yulihartati and Veri, (2025) showed that the lack of institutional support also slows down teachers' adaptation to technology.

This phenomenon demonstrates a significant gap between the demands of 21st-century learning and the actual preparedness of teachers in the field. Teachers are required to integrate technology, design problem-solving-based learning, and foster students'

critical, analytical, creative, and reflective thinking skills. However, these competencies cannot be developed instantly but require a continuous process through training and experience (Janah, 2022). Furthermore, deep learning also requires teachers to be able to create a learning environment that supports in-depth exploration and reflection (Jeet & Pant, 2023). However, in practice, technology is often used separately from pedagogical strategies, resulting in digital learning that does not produce meaningful learning experiences.

Although various studies have examined Deep Learning and teacher competencies within the TPACK framework, most of these studies are partial and have not comprehensively integrated the two concepts within the context of teacher readiness, particularly at the elementary school level. Previous studies tended to focus on technological aspects or global trends in Deep Learning without linking them to teachers' pedagogical readiness in the field (Wibawa et al., 2022; Ramachandran et al., 2023). Furthermore, research on TPACK generally only highlights competency mastery without directly linking it to Deep Learning approaches (Hanik et al., 2022; Janah, 2022). Furthermore, most studies were conducted at the secondary education level or in urban areas, thus not representing conditions in semi-urban areas that have different characteristics in terms of technology access and teacher readiness (Muharam et al., 2025).

Based on this, there is a clear research gap, namely the lack of studies that simultaneously integrate Deep Learning as a pedagogical approach with TPACK as a framework for analyzing teacher readiness, as well as the limited research that examines the readiness of elementary school teachers in the context of semi-urban areas. Therefore, this study contributes by simultaneously integrating the Deep Learning approach and the TPACK framework in analyzing the readiness of elementary school teachers in semi-urban areas. Unlike previous studies that tend to examine TPACK and Deep Learning separately or at the secondary education level, this study not only measures the level of teacher readiness but also identifies the gaps between TPACK components and the contextual factors that influence them, thus providing theoretical and practical contributions to the development of learning in the Digital 5.0 era.

2. Method

2.1. Research Design

This study employed a mixed methods approach with an explanatory sequential design, in which quantitative data were collected and analyzed in the initial stage, followed by qualitative data collection to deepen and explain the quantitative findings (Creswell & Plano Clark, 2023). This approach was selected

because it enables researchers to obtain a comprehensive understanding of teacher readiness to implement Deep Learning in the Digital 5.0 era, both numerically and contextually. The main variable in this study was teacher readiness to implement TPACK-based Deep Learning. The research instrument incorporated the Technological Pedagogical Content Knowledge (TPACK) framework, which was grouped into the main teacher competencies, namely pedagogical, technological, professional, personal, and social competencies, to measure teachers' integrative readiness for implementing Deep Learning in the Digital 5.0 era.

2.2. Participants

The study population comprised all elementary school teachers in Ponorogo Regency

who implemented the Independent Curriculum. The sample was determined using a simple random sampling technique based on the Slovin formula from a total population of 4,031 elementary school teachers in Ponorogo Regency. With a 5% margin of error, a sample size of 364 respondents was obtained. This technique provided an equal opportunity for each member of the population to be selected as a sample, thereby increasing the representativeness of the data. The sample was distributed proportionally based on sub-district area to ensure representation of respondents from various school conditions.

2.3. Instrument

The research instrument is in the form of a questionnaire compiled based on a framework TPACK from Koehler and Mishra (2009), which includes seven components, namely: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), dan Technological Pedagogical Content Knowledge (TPACK).

The instrument consisted of 57 statements developed through indicator identification, item development, readability testing, and construct validation. Respondents were asked to provide answers using a 5-point Likert scale: 1 (Never), 2 (Rarely), 3 (Sometimes), 4 (Often), and 5 (Always). This scale was used to capture the variation in teacher responses in greater detail and minimize the tendency to choose neutral answers (Sofyan et al., 2023).

Initial validation of the instrument was conducted through expert judgment by experts in the field of educational technology and pedagogy to ensure content validity. Furthermore, construct validity was tested using Confirmatory Factor Analysis (CFA) to ensure the suitability between the indicators and the measured TPACK constructs, with model fit criteria including $CFI \geq 0.90$, $TLI \geq 0.90$, $RMSEA \leq 0.08$, and factor loading ≥ 0.50 . The CFA model in this study refers to the structure of seven TPACK components, namely TK, PK, CK, PCK, TCK, TPK, and TPACK which are modeled as first-order latent constructs in a multidimensional framework. Each construct is analyzed simultaneously to comprehensively represent teacher readiness in implementing TPACK-based Deep Learning.

Each instrument item is mapped to a TPACK component based on indicator suitability. Items 1–8 represent Technological Knowledge (TK), items 9–18 represent Pedagogical Knowledge (PK), items 19–26 represent Content Knowledge (CK), items 27–34 represent Pedagogical Content Knowledge (PCK), items 35–42 represent Technological Content Knowledge (TCK), items 43–50 represent Technological Pedagogical Knowledge (TPK), and items 51–57 represent Technological Pedagogical Content Knowledge (TPACK).

The score for each component is calculated based on the average value of the items that represent the construct. The division of items into each component is also supported by the results of the CFA analysis which shows that each indicator has a factor loading ≥ 0.50 on the appropriate construct. In addition to the questionnaire, this study also used interview guidelines, observation sheets, and documentation formats as qualitative instruments to support and strengthen the analysis results.

2.4. Data Collection

Quantitative data collection was conducted online via Google Forms and offline at schools with limited internet access. This approach was used to ensure representativeness of respondents from various school settings. The qualitative phase was conducted through semi-structured interviews with a number of teachers selected purposively based on quantitative results, as well as limited observations of the learning practices of several selected informants and the collection of documentation including teaching modules or lesson plans, learning media, and evidence of learning activities as supporting data to strengthen the interview results. Interviews focused on exploring the supporting and inhibiting factors in the integration of technology, pedagogy, and content. The same informants were also the subjects of observation and documentation to ensure consistency and depth of data in the triangulation process.

2.5. Data Analysis

Prior to descriptive analysis, construct validity testing was conducted using CFA to ensure that the instrument had a factor structure that was in accordance with the TPACK framework. Quantitative data were analyzed using descriptive statistics to calculate mean scores and determine teacher readiness categories based on score ranges: 4.21–5.00 (Very Ready), 3.41–4.20 (Ready), 2.61–3.40 (Fairly Ready), 1.81–2.60 (Less Ready), and 1.00–1.80 (Not Ready). Qualitative data were analyzed using Miles et al. (2019) interactive model through data reduction, data presentation, and conclusion drawing to identify key themes. Data integration was performed by linking quantitative and qualitative results in a complementary manner during the interpretation stage, thus gaining a deeper understanding of teacher readiness in implementing TPACK-based Deep Learning.

3. Results and Discussion

3.1. Results

The research results are presented in several sections, namely the results of the overall level of teacher readiness, analysis based on TPACK components, and the results of integrating quantitative and qualitative findings.

3.1.1. Instrument Validity and Reliability Test

Validation of the research instrument was conducted by two expert validators to determine the level of instrument feasibility before being used in research data collection. The assessment was based on three aspects, namely relevance (R), clarity (K), and construct suitability (C). Each aspect has a score range of 1–4, so the maximum score for each item is 12. The number of instrument items validated was 57 items with an overall maximum score of $57 \times 12 = 684$. The validation results from expert 1 obtained a total score of 648, while expert 2 obtained a total score of 667. The results of the calculation of the percentage of feasibility for each validator are presented in the following table.

Table 1. Results of Instrument Validation by Experts

Validator	Score Obtained	Maximum Score	Percentage	Category
Member 1	648	684	94.74%	Highly Valid
Member 2	667	684	97.51%	Highly Valid

The average percentage of instrument eligibility is calculated using the formula 1

$$\text{Average Percentage} = \frac{94.74\% + 97.51\%}{2} = 96.12\% \quad (1)$$

Based on these results, an average feasibility percentage of 96.12% was obtained,

which falls into the very valid/very feasible category because it is in the range of 81%–100%. The validation results indicate that the research instrument has indicators that align with the research objectives, item wording is clear, and constructs are aligned with the theory used in the study. Furthermore, the instrument is deemed capable of representing the aspects to be measured, making it suitable for use as a research data collection tool without requiring major revisions.

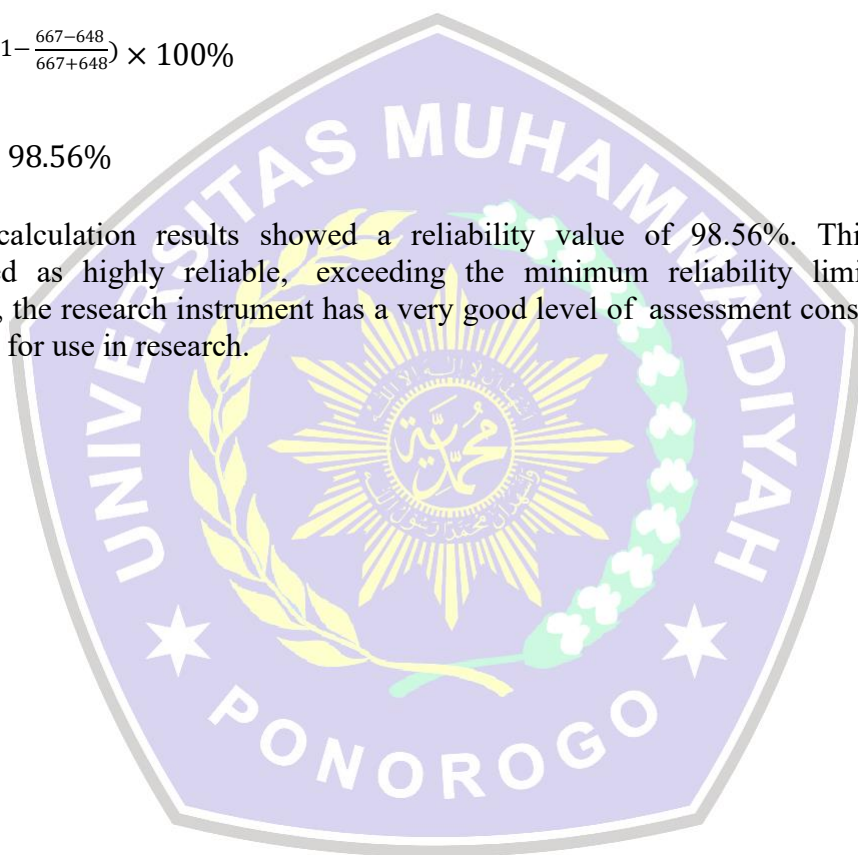
The instrument's reliability test was conducted using the Percentage Agreement (PA) technique to determine the level of consistency of assessments between validators. Reliability was calculated based on the total validation scores from two expert validators. The first validator gave a total score of 648, while the second validator gave a score of 667. Reliability was calculated using the Percentage Agreement formula as follows:

$$PA = \left(1 - \frac{A-B}{A+B}\right) \times 100\% \quad (1)$$

$$PA = \left(1 - \frac{667-648}{667+648}\right) \times 100\%$$

$$PA = 98.56\%$$

The calculation results showed a reliability value of 98.56%. This value is categorized as highly reliable, exceeding the minimum reliability limit of 75%. Therefore, the research instrument has a very good level of assessment consistency and is suitable for use in research.



3.1.2. Research Data Analysis

3.1.2.1. Pedagogical Competence

Based on the results of descriptive analysis of indicators Pedagogical Deep Learning, it is known that the minimum value is 46 and the maximum value is 74 with a total of 5 classification categories. The length of the class interval is calculated using the formula and rounded to 6. Thus, the length of the class interval on the indicator Pedagogical Deep Learning is 6. Based on these results, the categorization of the Pedagogical Deep Learning indicator is presented in Table 2.

Table 2. Categories of Pedagogical Indicators

Interval Shoes	Category	Frequency
46-51	Very Low	2
52-57	Low	10
58-63	Currently	213
64-69	High	130
70-75	Very high	9

Based on the results of the indicator categorization Pedagogical Deep Learning, it is known that the majority of respondents are in the medium category with a frequency of 213 respondents. Furthermore, the high category has a frequency of 130 respondents, the low category has 10 respondents, the very high category has 9 respondents, and the very low category has 2 respondents. These results indicate that the level of Pedagogical Deep Learning respondents tend to be in the medium to high category.

3.1.2.2. Technological Competence

Based on the results of descriptive analysis of variables Pedagogical, it is known that the minimum value is 25 and the maximum value is 55 with a total of 5 classification categories. The result of the calculation of the length of the class interval is 6. Based on these results, the categorization of the Technology Competence indicator is presented in Table 3.

Table 3. Categories of Technology Competence indicators

Interval Shoes	Category	Frequency
25-30	Very Low	1
31-36	Low	3
37-42	Currently	21
43-48	High	290
49-55	Very high	49

Based on the categorization of deep learning technology competency indicators, the majority of respondents (290 respondents) were in the high category, followed by 49 in the very high category. Meanwhile, 21 respondents were in the moderate category, 3 in the low category, and 1 in the very low category. This indicates that respondents' technological competency levels tend to be high.

3.1.2.3. Professional Competence

Based on the results of the descriptive analysis of the readiness for deep learning of the teacher professional competency indicator, it is known that the minimum value is 24 and the maximum value is 40 with a total of 5 classification categories. The results of the calculation of the length of the class interval are 3, so that the variable assessment category is 24. Based on these results, the categorization of the Professional Competence indicator is presented in Table 4.

Table 4. Categories of Professional Competence indicators

Interval Shoes	Category	Frequency
24–26	Very Low	1
27–29	Low	7
30–32	Currently	69
33–35	High	247
36–40	Very high	40

Based on the categorization of deep learning readiness based on professional competency indicators, the majority of respondents (247) were in the high category. Furthermore, 69 respondents were in the moderate category, 40 respondents in the very high category, 7 respondents in the low category, and 1 respondent in the very low category. This indicates that the respondents' level of professional competency tends to be high.

3.1.2.4. Personality Competence

Based on the descriptive analysis of the Personality variable, the minimum score is 27, and the maximum score is 40, with 5 classification categories. The calculation of the class interval length is 3. Based on these results, the categorization of the Personality Competence indicator is presented in Table 5. The mean score was 34.03, indicating that the respondents' Personality Competence was in the moderate category.

Table 5. Personality Competency Indicator Categories

Interval Shoes	Category	Frequency
27–29	Very Low	3
30–32	Low	79
33–35	Currently	221
36–38	High	47
39–41	Very high	14

Based on the results of variable categorization Personality, the majority of respondents were in the medium category, as many as 221 respondents. In addition, there were 79 respondents in the low category, 47 respondents in the high category, 14 respondents in the very high category, and 3 respondents in the very low category. This indicates that the level of competency indicators personality respondents tend to be in the moderate category.

3.1.2.5. *Social Competence*

Based on the results of the descriptive analysis of the Social Competence indicator, the minimum score was 19 and the maximum score was 35, with five classification categories. The class interval was calculated to be 4. Based on these results, the categorization of the Social Competence indicator is presented in Table 6.

Table 6. Social Competence Indicator Categories

Interval Shoes	Category	Frequency
19-22	Very Low	1
23- 26	Low	12
27-30	Currently	272
31- 34	High	69
35- 38	Very high	10

Based on the results of the competency indicator categorization social, the majority of respondents were in the medium category, as many as 272 respondents. In addition, there were 69 respondents in the high category, 12 respondents in the low category, 10 respondents in the very high category, and 1 respondent in the very low category. This indicates that the level of Social respondents tend to be in the moderate category.

3.1.2.6. *Teacher Readiness for Implementing Deep Learning*

Based on the results of the descriptive analysis of the combined indicator variables, it is known that the minimum value is 159 and the maximum value is 244 with a total of 5 classification categories. The class interval was calculated to be 17. Based on these results, the categorization of teacher readiness for implementing Deep Learning is presented in Table 7.

Table 7. Teacher Readiness Categories for Implementing Deep Learning (Composite Variable)

Interval Shoes	Category	Frequency
159-175	Very Low	2
176- 192	Low	16
193-209	Currently	262
210- 226	High	74
227- 244	Very high	10

Based on the combined indicator variable categorization results, the majority of respondents (262) were in the moderate category. Furthermore, 74 respondents were in the high category, 16 in the low category, 10 in the very high category, and 2 in the very low category. This indicates that the level of the combined indicator variable for respondents tends to be in the moderate category.

3.1.2.7. *Deep Learning Support*

This subchapter describes various forms of support for the implementation of Deep Learning in the learning process. The support examined includes school infrastructure, school leadership, curriculum

alignment, and a conducive work environment. These factors are considered important in creating conditions that facilitate the effective implementation of Deep Learning. The distribution of respondents' responses regarding these supporting factors is presented in Table 8.

Table 8. Analysis of Respondents' Answers Supporting the Implementation of Deep Learning

Indicator	Respondents' answers	Frequency of answers
School infrastructure support	Never	3
	Sometimes	2
	seldom	161
	Often	126
	Always	72
Leadership support (principal etc.)	Respondents' answers	Frequency of answers
	Never	1
	Sometimes	12
	seldom	0
	Often	131
Appropriate curriculum	Always	220
	Respondents' answers	Frequency of answers
	Never	0
	Sometimes	42
	seldom	0
Conducive work environment	Often	191
	Always	191
	Respondents' answers	Frequency of answers
	Never	0
	Sometimes	44
	seldom	1
	Often	167
	Always	152

Based on the respondents' answers, support for the implementation of deep learning was generally positive. Leadership support received the highest responses in the "always" and "often" categories, indicating the active role of school principals and management in supporting the learning process. Curriculum alignment and a conducive work environment were also rated positively by most respondents. Meanwhile, school infrastructure still needs further improvement, particularly in the availability and stability of digital technology facilities, such as equitable internet access and adequate devices. Some respondents indicated that this support had not yet been provided optimally across all schools. Overall, the implementation of deep learning has received fairly strong support from various school-related aspects.

3.1.2.8. Deep Learning Obstacles

The obstacles to the implementation of Deep Learning were examined in terms of time availability, access to technology, administrative burden, and training. These factors may affect teachers' ability to implement Deep Learning effectively in the learning process. The distribution of respondents' responses regarding these obstacles is presented in Table 9.

Table 9. Analysis of Respondents' Answers to Obstacles to Deep Learning Implementation

Indicator	Respondents' answers	Frequency of answers
Time availability	Never	0
	Sometimes	21
	seldom	1
	Often	166
	Always	176
Access to technology (internet etc.)	Respondents' answers	Frequency of answers
	Never	0
	Sometimes	44
	seldom	1
	Often	240
Administrative burden	Always	79
	Respondents' answers	Frequency of answers
	Never	0
	Sometimes	58
	seldom	0
Training	Often	122
	Always	85
	Respondents' answers	Frequency of answers
	Never	0
Indicator	Respondents' answers	Frequency of answers
	Sometimes	21
	seldom	0
	Often	263
	Always	80

Based on the results of respondents' answers, the factors inhibiting implementation deep learning teachers still feel that they are experiencing significant challenges. Time availability is a dominant obstacle, with the majority of respondents answering "often" and "always," indicating that time constraints impact learning implementation. Access to technology, such as the internet, is also a common obstacle. Furthermore, administrative burdens are considered to hinder the learning process, with most respondents choosing the "often" and "always" categories. Training is also a significant obstacle, indicating that teacher training and competency development needs to be improved. Overall, time constraints, technology access, administrative burdens, and training be a factor that influences the optimization of implementation deep learning at school.

3.1.3. Qualitative Analysis of Respondents' Interview Answers

The research results show that elementary school teachers' readiness to implement deep learning in the Digital 5.0 era varies based on their level of readiness, including high, medium, and low. The analysis was conducted through source triangulation, including interviews, observations, and documentation, to obtain valid data related to factors supporting and inhibiting teacher readiness.

3.1.3.1. Teachers with High Readiness Scores

Teachers with high readiness demonstrated a good understanding of the concept of deep learning, emphasizing conceptual understanding, critical thinking, and reflection, as well as linking material to students' real lives. They understood that learning is not solely oriented toward memorization, but also

toward students' ability to explore, analyze, and interpret learning. Interviews indicated that teachers implemented contextual and meaningful learning through group discussions, inquiry, problem-based learning, and project-based learning. Furthermore, teachers utilized learning technologies such as instructional videos, PowerPoint, and Google Classroom to support student understanding. Factors supporting high teacher readiness included a strong pedagogical understanding, the use of active learning methods, school technology support, collaboration with fellow teachers through Teacher Working Group activities, and teacher motivation to continuously innovate in learning.

Teachers also strive to create a joyful learning environment through educational games, discussions, and active classroom interactions. However, several inhibiting factors remain for high-level teachers, including limited learning time, a tight curriculum, and technology utilization that does not fully support the development of students' Higher Order Thinking Skills (HOTS). Interview results were reinforced by observations that showed that teachers implemented meaningful, mindful, and joyful learning within an active and interactive classroom environment. Teachers also utilized active methods and formative assessments in their learning. Furthermore, documentation showed that learning materials included HOTS-based objectives, the use of digital media, and process-based assessments.

3.1.3.2. *Teachers with Medium Readiness Score*

Teachers with moderate readiness are beginning to understand the concept of deep learning as active and meaningful learning, but this understanding is not yet fully in-depth, both theoretically and practically. Teachers have tried to relate the material to students' daily lives and implemented simple project-based learning. Interviews indicate that teachers use basic digital media such as instructional videos and PowerPoint to support learning. Teachers also receive support through KKG activities and Independent Curriculum training, which helps them understand deep learning-based learning. Supporting factors for teacher readiness in the moderate category include teacher motivation to improve the quality of learning, the use of basic digital media, and support from training and teacher learning communities. However, the implementation of deep learning has not been consistently implemented in every lesson.

The inhibiting factors identified included insufficient systematic reflection on learning, suboptimal technology integration, limited process assessment, and differences in student abilities and readiness for active learning. Furthermore, some students are still accustomed to rote learning, thus not engaging in active critical and reflective thinking.

Observations show that teachers have begun using active learning methods and linking material to students' real-life situations. However, process-based assessments and technology integration in collaborative activities have not been optimally implemented. Learning documentation also

shows the use of digital media and active methods, but they have not been systematically integrated to support deep learning.

3.1.3.3. *Teachers with Low Readiness Scores*

Teachers in the low readiness category still struggle to fully grasp the concept of deep learning. Learning is still dominated by lecture methods and one-way communication, resulting in students being passive in the learning process. Interviews indicate that teachers still experience limited digital literacy and difficulty using learning technology. Learning technology is used sparingly and has not been integrated with active learning or the development of students' critical thinking skills. Supporting factors identified in this category include school support and teacher motivation to learn and keep up with developments in digital learning. However, inhibiting factors are more dominant, including a low understanding of deep learning, limited technological facilities, conventional learning, and an under-implementation of the assessment process.

Observations show that learning remains teacher-centered, with very limited use of active learning methods. Students are also less active in discussions and are not yet accustomed to reflecting on their learning. Meanwhile, learning documentation shows that learning tools do not yet demonstrate a systematic integration of deep learning and technology.

3.2. *Discussion*

The results of the study show that the readiness of elementary school teachers in implementing deep learning in the Digital 5.0 era, teachers tend to be in the moderate category. These findings indicate that teachers already possess basic pedagogical, technological, professional, personal, and social readiness. However, its implementation has not been fully optimal in supporting in-depth learning. This could be because readiness is measured not only by competency, but also by the ability to consistently apply it in learning. According to Harjun et al., (2026), factors that influence the implementation of deep learning are not only teacher readiness but school facilities and infrastructure also play a significant role. Furthermore, Nadawina et al. (2025) explained the complexity of deep learning integration due to the Indonesian education system's rich social, cultural, and geographical diversity. This condition is evident from the results of descriptive analysis, which showed that the majority of respondents were in the medium to high category for almost all teacher competency indicators. In the pedagogical competency indicator, the majority of teachers were in the medium to high category. These findings indicate that teachers are beginning to understand the importance of learning that is oriented towards conceptual understanding, critical thinking, and meaningful learning.

The results of this study are in line with the concept deep learning as proposed by Fullan et al., (2017), which emphasizes meaning-based learning, reflection, and problem-solving skills in real contexts. Furthermore, meaningful learning aligns with Piaget and Vygotsky's constructivist theories, which

emphasize that knowledge is built through experience and social interaction in learning (Fatmawaty, 2024). Interview findings with high-stakes teachers indicate that teachers have used group discussions, inquiry learning, problem-based learning, dan project-based learning quite consistently. This shows that teachers are starting to shift the learning paradigm from teacher centered become student centered. In line with the opinion of Kerimbayev et al. (2023) modern education demands a paradigm shift from teacher-centered learning (TCL) to student-centered learning (SCL).

This finding supports the statement from Sastradinata, (2023) which states that the implementation of active learning can improve students' critical, reflective, and collaborative thinking skills in 21st century learning. However, teachers still face obstacles in the form of limited learning time and tight curriculum targets so that implementation is deep learning cannot be implemented optimally. This was also found in another study by Dinata et al., (2025) that teacher competencies in reflective, literacy, and philosophical aspects were not sufficient to support the deep learning approach. In terms of technological competency indicators, the research results show that the majority of teachers are in the high category. Teachers have used digital media such as learning videos, PowerPoint, Google Classroom, and other learning applications in the learning process.

These findings indicate that teachers are beginning to develop Technological Knowledge (TK) skills within the TPACK framework, as proposed by Ajizah and Huda (2020). The use of this technology helps teachers deliver material in a more engaging and interactive manner. However, observations and documentation indicate that technology has not been fully utilized to develop students' higher order thinking skills (Francom, 2020). This is in line with Leow and Neo (2023) the integration of creativity, collaboration, and technology in learning is important to prepare students to face global challenges and requires support and cooperation between educators and policy makers in creating a conducive learning environment, then the use of technology is still dominant as a tool for presenting material and is not optimal in supporting collaborative, reflective, and exploratory activities of students. This finding is in line with research by Entriza and Puspitasari (2025) which states the integration of technology in learning is often limited to technical aspects and does not fully support in-depth learning. In terms of professional competency indicators, the majority of respondents were in the high category. This indicates that teachers have undertaken professional development efforts through Independent

Curriculum training, teacher learning communities, and Teacher Working Group (KKG) activities (Bragg et al., 2021). This aligns with the findings of Pawartani and Suciptaningsih (2024) that teacher competency development in implementing the Independent Curriculum is carried out through training, mentoring, collaboration, utilization of the Independent Teaching Platform, monitoring, and sharing of good practices.

This finding also shows that professional collaboration is a supporting factor for implementing deep learning. According to Tamsiyati et al. (2025), collaboration between teachers and professional learning communities is an important strategy in improving teacher readiness to face educational transformation in the Society 5.0 era. Meanwhile, in terms of personality and social competency indicators, the results of the study showed that most teachers were in the moderate category. Teachers have had the motivation to innovate and create a joyful learning atmosphere through discussions, educational games, and active interactions (Weddle, 2022). This finding is in accordance with the opinion of Yang (2022) who stated that teachers' emotional intelligence influences the ability to build a learning atmosphere that is safe, comfortable, and supports student development. However, teachers in the middle and low categories still experience difficulties in developing systematic learning reflections and developing reflective communication that encourages students to think critically. Some students are also still accustomed to a culture of rote learning, making them less active in discussions and reflection. This situation indicates a shift in the learning paradigm toward deep learning requires an adaptation process that not only involves teachers, but also student readiness and the school's learning culture. The research also shows that school support is a crucial factor in implementing deep learning. School leadership support received the highest response compared to other indicators. This demonstrates the strategic role principals play in encouraging learning innovation, providing facilities, and developing teacher competencies (Natalia & Pranata, 2025).

This finding supports the research of Wohlfart and Wagner (2023) which states that supportive school leadership can increase teacher readiness in facing the digital transformation of education. However, the factors inhibiting implementation deep learning are still quite dominant. Limited learning time, access to technology, administrative burden, and lack of training are the main obstacles perceived by teachers. The majority of respondents stated that limited time and administrative burden make it difficult for teachers to design in-depth and reflective learning. This finding aligns with research by Nadawina et al. (2025), which states that teachers' administrative burden is one of the causes of the low optimization of technology-based learning innovations.

Based on the results of interviews, observations, and documentation, differences in teacher readiness in each category were observed. Teachers in the high category were able to implement meaningful, mindful, and joyful learning more optimally than teachers in the medium and low categories. Meanwhile, teachers in the low category were still dominated by conventional learning, limited use of technology, and assessments that focused on final results. Overall, the results of the study indicate that the implementation of deep learning in elementary schools in the Digital 5.0 era requires continuous support through improving teachers' pedagogical and technological competencies, strengthening professional learning communities, reducing administrative burdens, and providing adequate technological facilities. Thus, teachers can be better prepared to create meaningful, reflective learning and be able to develop students' 21st-

century skills.

3.3. *Implications*

The results of this study have theoretical and practical implications for the implementation of deep learning in elementary schools in the Digital 5.0 era. Theoretically, this study strengthens the concept of deep learning as meaningful, mindful, and joyful learning that requires the integration of pedagogical, technological, professional, personal, and social competencies of teachers. The findings of this study also support the TPACK framework proposed by Mishra and Koehler (2006), which states that the integration of technology, pedagogy, and material mastery are essential components of 21st-century learning.

Practically, the research results show that teacher readiness in implementing deep learning still requires ongoing support through professional training, improving digital literacy, and strengthening teacher learning communities such as teacher working groups. Schools and policymakers need to improve technological infrastructure, provide ongoing training, and reduce the administrative burden on teachers so that deep learning implementation can run more optimally. Furthermore, school principals have a strategic role in creating a school environment that supports learning innovation and a reflective culture in the teaching and learning process. This research also implies that the implementation of deep learning should not only focus on the use of technology, but also on shifting the learning paradigm from teacher-centered to student-centered learning, which can develop students' critical thinking skills, creativity, collaboration, and reflection.

3.4. *Limitations*

This study has several limitations that should be considered when interpreting the results. First, the study was conducted only with elementary school teachers in Ponorogo Regency, so the results cannot be broadly generalized to other regions with different conditions and technological readiness. Second, the study used self-report questionnaires and interviews, which still allow for subjectivity in respondents' responses. Although

source triangulation through observation and documentation was conducted to strengthen data validity, potential bias in respondents' perceptions remains. Third, this study focused solely on teacher readiness for deep learning implementation and did not fully examine the impact of deep learning implementation on student learning outcomes. Furthermore, categorizing teacher readiness into high, medium, and low does not fully reflect the complexity of teacher competency in actual learning practices. Therefore, further research is recommended that involves a broader research area, examines student perspectives and learning outcomes, and uses a longitudinal approach to assess the sustainability of deep learning implementation in elementary schools.

4. Conclusion

This study concludes that elementary school teachers' readiness to implement deep learning in the Digital 5.0 era is moderate. Teachers generally possess adequate pedagogical, technological, and professional competencies, although their application is not yet optimal across all aspects of learning. The implementation of deep learning is supported by school leadership, teacher collaboration, training, motivation to innovate, and the use of technology. However, obstacles remain, including time constraints, administrative burdens, inadequate technological resources, low digital literacy, and a lack of ongoing training. Therefore, improving teacher competency, strengthening technological infrastructure, and supporting educational policies are needed to ensure the optimal implementation of meaningful, reflective, and 21st-century skills-oriented learning

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

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