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TEACHER READINESS LEVEL IN IMPLEMENTING THE DEEP LEARNING MATHEMATICS APPROACH TO SENIOR HIGH SCHOOL STUDENTS IN BATU CITY

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ABSTRACT

This study aims to measure the readiness of high school mathematics teachers in Batu City to implement Deep Learning in the context of the Industry 4.0 Era. The research employed a quantitative descriptive survey approach. A sample of 60 teachers was selected using purposive sampling from active teachers in public and private high schools in Batu City. Data were collected through a closed questionnaire referring to four core teacher competencies: pedagogical, personality, professional, and social. Data analysis was conducted using descriptive statistics in the form of averages, percentages, and readiness level categories. The results of the study showed that the majority of teachers (63.33%) were in the Ready category in the pedagogical aspect, 32.5% were Less Ready, and 4.17% were Very Ready. In the personality aspect, 37.22% of teachers were Ready, 37.22% Less Ready, and 25.56% Very Ready. In the professional aspect, 51.11% of teachers were Less Ready, 28.33% Very Ready, and 20.56% Ready. In the social aspect, 51.67% of teachers were Less Ready, 25.83% Very Ready, and 22.50% Ready. These findings indicate that successful implementation of Deep Learning requires strengthening teacher competencies through ongoing training, learning communities, and school policy support that is adaptive to developments in the digital era.
Keywords: Deep Learning, Teacher Readiness, Teacher Competence, Industry Era 4.0, Mathematics Learning.

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PRELIMINARY

Through the use of technologies such as automation, big data, and networks that enhance the learning process, the Fourth Industrial Revolution has transformed many aspects of life, including the education industry (Kayembe & Nel, 2019). According to (Fonna, 2019) rapid technical developments in various sectors, especially in artificial intelligence, robotics, blockchain, nanotechnology, quantum computing, biotechnology, Internet of Things, 3D printing, and autonomous vehicles. Indonesia is entering the era of the Industrial Revolution 4.0, where education is expected to prepare human resources with 21st-century skills such as creativity, critical thinking, communication, and collaboration. In addition, other essential competencies like leadership, digital literacy, and entrepreneurship are becoming key focuses to face the challenges and opportunities brought by rapid technological advancement (Gularso, 2021).

The rapid development of technology has ushered us into the era of Industry 4.0, which emphasizes automation, artificial intelligence, and the integration of digital technologies into the industrial sector (Afif Husain Yasir & Ahmad Gunawan, 2024). In this era, smart systems, Internet of Things (IoT), big data, and cloud computing are transforming traditional industries into more efficient and interconnected systems. Industry 4.0 also significantly impacts various sectors beyond manufacturing, including education, by encouraging digital transformation, personalized learning, and the development of future-ready skills to meet the demands of a technology-driven world (Haqqi et al., 2019). In this era of disruption, new challenges have emerged for the world of education, where the learning process is no longer limited to physical space alone, but has penetrated the digital and even biological realms more broadly (Savitri, 2019).

Some of the problems that have emerged in the era of society 4.0 related to education include the occurrence of a digital divide where with the increasingly strong integration of physical and virtual spaces, inequality in access to technology and digital resources is still a major challenge (Br.Sinulingga & Nasution, 2024). Then the development of technology such as artificial intelligence, the Internet of Things, and automation requires education to adapt, but not all institutions are able to adjust the curriculum and teaching methods to the needs of the industry (Tahar et al., 2022). In addition, other problems in the Society 5.0 era require creativity, critical thinking, collaboration, leadership, and digital literacy, but not all students and educators are ready to develop them (Khoiriah et al., 2023). Meanwhile, referring to the issues in mathematics learning, a study by found that students’ difficulties are influenced by a lack of seriousness in problem-solving, dependence on peers for answers, and reluctance to ask teachers for help (Miftahudin & Putra, 2025). The study recommends strengthening fundamental concepts, employing varied teaching methods, and fostering students' independence and critical thinking to improve their mathematical abilities.

One innovative approach that can be adopted to address this challenge is deep learning, according to (Lase, 2019) is relevant learning strategies in the current era emphasize meaningful learning, namely learning that links material to students' real experiences, making it more relevant and contextual. In addition, teachers are required to have future competencies, a role as a counselor, an understanding of globalization, and the ability to adapt to technology, accompanied by creativity, humor, and the ability to teach holistically, which not only allows processing large amounts of data but also supports personalization of learning styles (A. K. Saputra, 2022). This approach has the potential to enrich the learning process amidst the complexity of the needs of the digital era. This is in line with the opinion of (Oktaviani, 2024) Deep learning driving major changes in this era with the ability to process big data and recognize complex patterns independently, making it more adaptive. A study from (Suwandi et al., 2024) that the model deep learning has great potential to improve the quality of learning and critical thinking skills of students in Indonesia.

A relevant learning approach today is Deep Learning, which emphasizes in-depth conceptual understanding, rather than simply memorizing information. Through this approach, students are encouraged to connect knowledge to real-life situations, analyze, solve problems, and develop new ideas critically and reflectively (Prawiyogi et al., 2025). The indicators are mindful learning, meaningful learning, and joyful learning. This makes learning more meaningful for students (Mystakidis, 2021). According to a study highlights the importance of meaningful learning in developing critical thinking and problem-solving skills, especially for 21st century education. Deep Learning supports more meaningful, mindful, and enjoyable learning (Suwandi et al., 2024). Deep learning can be applied to mathematics, for example, through Project-Based Learning (PBL). Students create a school budget plan by applying the concepts of percentages, comparisons, and graphs. This activity makes learning more meaningful, reflective, and enjoyable. Another example is students working collaboratively to solve geometry problems using a geoboard or GeoGebra. Through discussion and visualization, students learn deeply, focused, and creatively, making learning more enjoyable.

Deep learning is increasingly important amidst rapid global change and the demands of preparing future generations (Muvid, 2024). This concept is considered relevant because it promotes flexible and meaningful education. Research by (Gularso, 2021) shows that China discusses deep learning extensively, although it focuses more on the technological and machine learning aspects. The novelty of this study lies in its focus on measuring teacher readiness to implement deep learning. Unlike previous research that focused on technology or methods, this study emphasizes the importance of teacher readiness as a key factor in the successful implementation of deep learning in the digital era.

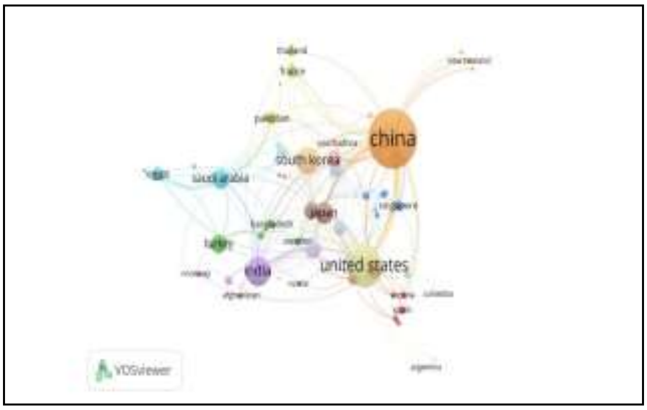

Figure 1. Visualization of Research Discussing Deep Learning

While immersive learning has a lot of potential to improve educational standards, teachers especially those in primary schools face significant obstacles in integrating technology and modifying immersive learning methodologies amidst the rapidly evolving educational landscape of the Industry 4.0 era. Teachers today are expected to be facilitators of learning who can help students develop character and higher-order thinking skills in addition to imparting knowledge. Therefore, it is very important to evaluate and improve teacher readiness in facing this paradigm shift in learning. This readiness includes a conceptual understanding of Deep Learning, pedagogical and technological skills, and an open attitude to change. Only with teachers who are holistically prepared, the Deep Learning approach is successfully applied to produce a generation that thinks critically, creatively, and adaptively in the Industry 4.0 era.

METHODS

This study employed a descriptive quantitative approach to measure and describe the readiness of high school mathematics teachers in Batu City to implement the Deep Learning approach in the context of the Industry 4.0 era. The population consisted of all mathematics teachers in public and private high schools in Batu City. A total of 60 actively teaching teachers were selected through purposive sampling, with the inclusion criteria being those who were still actively teaching mathematics during the study period. The research was conducted from May to June 2025.

Data were collected using an online questionnaire designed with a Likert scale to assess four aspects of teacher competence: pedagogical, personality, professional, and social. The validity of the instrument was confirmed through expert judgment, while reliability was tested using Cronbach's Alpha, with a result greater than 0.7 indicating that the instrument was reliable.

Data were analyzed descriptively and categorized into three levels of readiness: Very Ready, Ready, and Less Ready. The percentage of responses in each category was used to represent the distribution of teacher readiness. The research procedure included identifying the population and selecting the sample, developing and validating the instrument, distributing the online questionnaire, and finally, processing and analyzing the collected data. Teachers were given sufficient time to complete the questionnaire to ensure optimal participation.

Table 1. Teacher Readiness Categories

No	Interval	Criteria
1	3.68 - 5.00	Very Ready
2	2.34 - 3.67	Ready
3	1.00 - 2.33	Not Ready

The formula used in descriptive analysis (Zulqaidah et al., 2024) is as follows:

$$P = \frac{f}{n} x\ 100\%$$

Information:
P = Percentage
f = Number of respondents in each category
n = Number of Respondents

RESULT AND DISCUSSION

This study aims to measure the level of readiness of high school mathematics teachers in Batu City in implementing the Deep Learning approach in the context of the Industry 4.0 era. The results of the study were obtained through the distribution of questionnaires to 60 teachers from various public and private schools in Batu City. The instrument was compiled based on four indicators of teacher competence, namely pedagogical, personality, professional, and social. The following are the findings of researchers related to teacher readiness in implementing the Deep Learning approach in the Industry 4.0 era in mathematics learning.

Readiness Based on Pedagogical Competence

Indicators such as conceptual understanding of deep learning, preparation of learning objectives, planning of exploratory activities, and collaborative class management, with the following results.

Table 2. Teacher Readiness Categories Based on Average Scores

Indicator	Average Score	Category
P1	2,53	Ready
P2	2,38	Ready
P3	2.33	Not Ready
P4	2,53	Ready

The results show that P1 (understanding the characteristics of deep learning), P2 (being ready to formulate goals based on concepts and critical thinking), and P4 (being confident in managing collaborative classrooms) are categorized as Ready with average scores of 2.53, 2.38, and 2.53, respectively. Meanwhile, P3 (being able to design exploration, discussion, and reflection activities) is categorized as Not Ready with a score of 2.33. This indicates that teachers still need improvement in designing deep learning activities.

Table 3. Frequency distribution and percentage of teacher readiness

Indicator	Category	Number of Teachers (f)	Percentage (%)
P1	Very Ready	3	5.00%
	Ready	39	65.00%
	Not Ready	18	30.00%
P2	Very Ready	2	3.03%
	Ready	42	70.00%
	Not Ready	16	26.07%
P3	Very Ready	1	1.07%
	Ready	34	56.07%
	Not Ready	25	41.06%
P4	Very Ready	4	6.07%
	Ready	37	61.07%
	Not Ready	19	31.06%

The majority of mathematics teachers are in the Ready category on indicators P1, P2, and P4, indicating that they are quite prepared in understanding the characteristics of deep learning, setting learning objectives, and managing the classroom. However, on indicator P3, most teachers are in the Less Prepared category, indicating the need for improved skills in designing learning that involves student exploration, discussion, and reflection. These results are in line with research conducted (Suwandi et al., 2024), which recommends supporting the implementation of more effective deep learning, particularly by strengthening teacher training and providing adequate facilities.

Readiness Based on Personality Competence

Personality competencies include openness of attitude, being an example for students and being accustomed to reflecting, as per the researcher's findings.

Table 4. Teacher Readiness Categories Based on Average Scores

Indicator	Average Score	Category
P5	12,98	Ready
P6	13,05	Ready
P7	2.57	Ready

Table 5. Frequency Distribution and Percentage of Teacher Readiness

Indicator	Category	Number of Teachers (f)	Percentage (%)
P5	Very Ready	18	30%
	Ready	26	43,03%

	Not Ready	16	26,07%
P6	Very Ready	19	31,07%
	Ready	17	28,03%
	Not Ready	24	40,00%
P7	Very Ready	9	15.00%
	Ready	24	40.00%
	Not Ready	27	45.00%

In indicator P5 (open to change), the majority of teachers are categorized as Ready (43.03%) and Very Ready (30%), while 26.07% are still less ready. For P6 (ready to be a role model), 31.07% are very ready, 28.03% are ready, and 40% are less ready. Meanwhile, P7 (used to self-reflection) shows the highest percentage of teachers in the less ready category (45%), with 40% ready and only 15% very ready. This indicates the need for improvement, especially in P7.

Readiness Based on Professional Competence

Teachers' professional readiness in mastering teaching materials effectively and contextually. In addition, it will also be explained to what extent teachers are ready to utilize technology to support in-depth learning, as well as active participation of teachers in participating in training and competency development forums. The following are the researcher's findings.

Table 6. Teacher Readiness Categories Based on Average Scores

Indicator	Average Score	Category
P8	2.35	Ready
P9	2.32	Not Ready
P10	2.23	Not Ready

Table 7. Frequency distribution and percentage of teacher readiness

Indicator	Category	Number of Teachers (f)	Percentage (%)
P8	Very Ready	22	36.67%
	Ready	11	18.33%
	Not Ready	27	45.00%
P9	Very Ready	16	26.67%
	Ready	11	18.33%
	Not Ready	33	55.00%
P10	Very Ready	13	9,21%
	Ready	15	25.00%
	Not Ready	32	53.33%

Teachers' professional readiness was assessed based on their ability to master teaching materials, utilize technology to support deep learning, and actively participate in professional development forums. Indicator P8 represents the teacher's ability to master the subject matter effectively and contextually. Indicator P9 reflects the teacher's readiness to use technology to support deep learning, while P10 measures the teacher's active participation in training or teacher forums to improve competencies. Based on the findings in Table 6, only P8 falls under the “Ready” category with an average score of 2.35. This indicates that, on average, teachers feel adequately prepared in mastering teaching materials in a contextual manner. However, both P9 (average score 2.32) and P10 (2.23) fall into the “Not Ready” category, highlighting challenges in utilizing technology and engaging in professional development activities.

Table 7 further supports these findings through frequency and percentage distribution. In P8, although 36.67% of teachers are categorized as Very Ready, 45% are still Not Ready. The situation is more critical for P9 and P10, with 55% and 53.33% of teachers, respectively, classified as Not Ready. This clearly shows that while some teachers demonstrate readiness in terms of content mastery (P8), a significant number still lack readiness in using technology (P9) and in participating actively in professional development efforts (P10). These results indicate a pressing need for targeted interventions to enhance teacher readiness in the technological and professional development aspects of teaching. Strengthening these areas is crucial for empowering teachers to implement the Deep Learning approach effectively in the context of the Industry 4.0 era. These results are reinforced by the opinion of Professional competence of 45% in designing and implementing deep learning strategies that emphasize critical thinking, creativity, and fun learning.

Readiness Based on Social Competence

Table 8. Teacher Readiness Categories Based on Average Score

Indicator	Average Score	Category
P11	2,33	Not Ready
P12	2,18	Not Ready

Table 9. Frequency Distribution and Percentage of Teacher Readiness

Indicator	Category	Number of Teachers (f)	Percentage (%)
P11	Very Ready	12	20.00
	Ready	14	23.33
	Not Ready	34	56.67
P12	Very Ready	19	31.67
	Ready	13	21.67
	Not Ready	28	46.67

Based on the results presented in Tables 8 and 9, it is evident that teacher readiness in the aspects of open and supportive communication with students (P11) and collaboration with fellow teachers and educational staff (P12) is still lacking. The average scores for both indicators fall into the “Not Ready” category, with P11 scoring 2.33 and P12 scoring 2.18. These findings are reinforced by the frequency and percentage distribution in Table

9, which shows that 56.67% of teachers are categorized as Not Ready in P11 and 46.67% in P12. While there are teachers who fall into the “Very Ready” category 20% for P11 and 31.67% for P12 the overall results suggest a need for strategic interventions. Specifically, professional development programs focusing on enhancing teachers' communication skills and collaborative competencies are essential to ensure readiness in facing the demands of education, particularly within the context of Industry 4.0, which emphasizes connectivity, collaboration, and interpersonal effectiveness.

The results of this study reveal that the readiness of mathematics teachers in Batu City in implementing the Deep Learning approach in the Industry 4.0 era are in various categories, depending on the competency aspects studied. Based on the four indicators of teacher competency as formulated by Law Number 14 of 2005 concerning Teachers and Lecturers, namely pedagogical, personality, professional, and social competencies (Octavianingrum, 2020), this study shows that although there are aspects that are relatively ready, there are also many areas that still need strengthening.

Pedagogical competence aspects**,** most teachers showed readiness in understanding basic concepts of Deep Learning, setting learning objectives, and managing collaborative classes. The results of a study by (Utiarahman, 2020) the implementation of tiered training or workshops can improve pedagogical competence and mastery of the concept of teacher pedagogical competence. This finding confirms the results of a previous study by (Utiarahman, 2020), which stated that pedagogical competence includes the ability of teachers to design and implement meaningful and adaptive learning to the needs of the times. However, in terms of the ability to design exploratory, reflective, and discursive learning (P3), teachers are still classified as less prepared (41.06%). This shows that the implementation of Deep Learning which requires problem-based learning (problem-based learning) and in-depth exploration have not been fully understood as a practical approach in teaching and learning activities (H. Saputra, 2021). In fact, according to the theory of constructivism From Piaget and Vygotsky, meaningful learning is not just about conveying information, but encouraging students to actively build knowledge through interaction and reflection (Salsabila & Muqowim, 2024).

Meanwhile, in terms of personality competency, teachers appear relatively ready in terms of showing an open attitude and being a role model for students. However, self-reflection as part of teacher professionalism (P7) is a weak point, with 45% of teachers in the less prepared category. In fact, as emphasized by Schön (1983) in his theory about Reflective Practitioner, reflective ability is an important characteristic of a professional educator who is able to continue to develop in his/her practice (Nisya, 2019). Reflection allows teachers to evaluate their learning approaches, improve strategies, and adapt to the dynamics of 21st century learning (Widodo & Wardani, 2020).

Furthermore, in the professional competence dimension, it was found that only one of the three indicators fell into the ready category, namely mastery of teaching materials (P8), while the other two indicators, namely utilization of technology (P9) and participation in training or professional communities (P10), were in the less ready category. This is in line with the finding (Haq et al., 2023),which show that some teachers still have difficulty in utilizing learning technology optimally, even in the midst of the rapid digital transformation in the world of education. This is in contrast to the Industry 4.0 era, teachers are not only required to be technologically literate, but also able to combine technology with a pedagogical approach to create learning that personalized, collaborative, and based on artificial intelligence (AI) (Pustikayasa et al., 2023). Unpreparedness in this aspect can hinder the success of the implementation Deep Learning, which inherently relies on the utilization of digital resources and data-driven learning analytics.

The last aspect, namely social competence, also shows that teachers are still not ready, especially in the ability to collaborate and communicate effectively with students, fellow teachers, and the community. As many as 56.67% of teachers are classified as not ready to build social relations in the context of digital learning. This finding is in line with a study by (Barkah et al., 2024), which states that 21st century teachers must be collaborative professionals who work in networks and are able to build communication that supports holistic learning. Weaknesses in this social competence indicate that some teachers still work individually and are not yet accustomed to building an open and collaborative learning ecosystem, as required by the approach. Deep Learning (Mukhoyaroh et al., 2025).

Overall, the results of this study show that although there are bright spots in terms of conceptual and basic pedagogical readiness, the implementation Deep Learning as a whole still faces various challenges. According to (Hastuti & Sufianti, 2025), deep learning in organizations (including educational institutions) can only be realized if there is a continuous transformation of learning culture. Therefore, increasing teacher capacity cannot be done partially, but needs to be supported through a continuous professional development strategy that includes practice-based training, coaching, strengthening learning communities, and school policies that encourage digital learning innovation.

Teacher Readiness in Implementing Deep Learning

To understand the extent of teacher preparedness in applying deep learning approaches, the research categorized teacher readiness across four key competency aspects: pedagogical, personality, professional, and social. Each aspect was assessed and classified into three levels of readiness: Very Ready, Ready, and Less Ready.

Table 10. Teacher Readiness in Implementing Deep Learning

Aspect	Very Ready (%)	Ready (%)	Less Ready (%)
Pedagogical	4.17%	63.33%	32.50%
Personality	25.56%	37.22%	37.22%
Professional	28.33%	20.56%	51.11%
Social	25.83%	22.50%	51.67%

Based on the table above, the pedagogical aspect shows that most teachers are in the *Ready* category (63.33%), although only a few are *Very Ready* (4.17%), and 32.5% are still *Less Ready*. In the personality aspect, the proportion of *Very Ready* teachers (25.56%) and *Less Ready* teachers (37.22%) is fairly balanced, indicating a need to strengthen professional attitudes. The professional aspect shows the lowest readiness, with over half of the teachers (51.11%) falling into the *Less Ready* category and only 28.33% being *Very Ready*. A similar pattern is observed in the social aspect, where 51.67% of teachers are *Less Ready*. These findings suggest that although teachers demonstrate moderate readiness in pedagogical skills, there is a significant need to improve their professional and social competencies to effectively implement deep learning.

CONCLUSION

This study concludes that the readiness of high school mathematics teachers in Batu City in implementing the Deep Learning approach in the Industry 4.0 era is at varying levels and tends to be suboptimal overall. In terms of pedagogical competence, teachers show relatively good readiness in understanding basic concepts and managing learning, but are still weak in designing exploratory and reflective activities which are the core of Deep Learning. In terms of personality competency, teachers appear to have a positive attitude and are exemplary, but are still lacking in self-reflection as part of ongoing professional development.

The professional competence aspect is a major concern because it shows the low utilization of technology in learning and minimal teacher participation in training activities or professional forums. This is very crucial, considering the Deep Learning approach highly dependent on technology integration and teacher involvement in data-based learning and artificial intelligence. Meanwhile, in social competence, teachers still face obstacles in building effective communication and collaboration, two important elements in creating an immersive and interactive learning ecosystem.

Therefore, the implementation of Deep Learning not only requires conceptual readiness, but also practical, emotional, and social readiness. Efforts to improve teacher competence comprehensively through structured training, strengthening learning communities, and support for school policies oriented towards digital learning innovation are very necessary so that educational transformation in the Industry 4.0 era can be achieved sustainably and meaningfully.

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