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# AI-Based Teaching Materials for Deep Learning: An Analysis of Usage by Elementary School Teachers

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**ABSTRACT**

**Background/purpose.** This study investigates the development of AI-powered learning materials with the aim of enhancing elementary school teachers' profound learning. This is in consideration of the low utilization of AI technology in the development of learning materials in the teaching process. The primary objective of this study is to investigate the extent of utilization of AI-based learning materials among elementary school teachers.
**Materials/methods**. This study utilized quantitative descriptive study using a survey method with 231 teachers of elementary school in West Java, Indonesia, as participants.
**Results**. The findings show that the majority of teachers have begun incorporating AI-based teaching materials and find them useful in enhancing student comprehension and participation, despite ongoing issues of training and infrastructure.
**Conclusion**. The study concludes that instructional materials patronized by AI are capable of leveraging deep learning to the maximum in primary education, subject to sufficient training and infrastructure. The findings are likely to inform future research in formulating the professional development requirements of teachers for planning AI-enabled instructional materials for effective facilitation of deep learning.

## 1. INTRODUCTION

Over the past decade, access to Computer Science and Computational Thinking education has expanded significantly with various states adopting student learning standards, while technology, particularly Artificial Intelligence (AI), has grown more and more integrated into daily life and studies through various courses and certifications (Sinha et al., 2023). In education, AI enhances and enriches environments of learning through intelligent tutoring systems, intelligent agents, and intelligent collaborative learning systems (Salas-Pilco et al., 2022).

AI technology is employed to tailor learning to students' personal needs. AI can identify the characteristics of every learner, including their capacity, how they understand things, and their learning experience, and then supply relevant materials. With the application of AI and machine learning technologies, online teaching materials can be tailored and made relevant

to every learner (Zahara et al., 2023). The use of AI in creating teaching materials is reported to positively address the improvement of the learning outcomes of students, particularly in enabling Deep Learning. Deep Learning in education is concerned with in-depth understanding and not memorization through eliciting critical, analytical, and reflective thinking. This approach aims at enhancing the quality of learning by interaction, the development of higher-order thinking skills, and applying knowledge in real-life settings (Akmal et al., 2025). Deep learning has been one method of learning process, and it holds enormous meaning for knowledge retention and skill acquisition in cognitive capacity. Deep learning is characterized by conceptual knowledge and critical thinking that is associated with knowledge application and knowledge intrinsic motivation (Vasile, 2024). Deep learning is an inclusive learning process that enables the development, transmission, and application of knowledge systems of students. It demands active involvement and proactive learning, facilitating learners to deepen their knowledge incrementally through the learning process. This approach is credited with developing the creative potential in students and enhancing their critical thinking skills (Zhou et al., 2024).

Previous research has demonstrated the application of AI in educational arenas like collaborative learning systems, computerized exams, and personalized learning (Kamalov et al., 2023). AI has also been employed to develop intelligent web-based educational systems for enhancing English language education (Sun et al., 2021) as well as the cognitive literacy of secondary school teachers through AI-supported electronic imagery (Efriyanti et al., 2024). The application of AI at the primary level, however, remains low due to issues such as a shortage of proper technology infrastructure as well as the absence of training among teachers (Efriyanti et al., 2024).

This study examines to what extent teachers in elementary schools adopt AI-based education materials to optimize deep learning. While earlier studies have examined the use of AI in education, few of them consider addressing the issue within the context of secondary and tertiary education (Kamalov et al., 2023; Sinha et al., 2023; Zhai et al., 2024; Zhou, 2023). The novelty within this study is its exploration of the relatively uncharted context of AI-based education materials within the context of elementary education and its convergence with deep learning.

The core issue under discussion in this study is the poor application of AI technology in curriculum content development in the elementary teaching process (Efriyanti et al., 2024). The teachers at this level possess a great number of hindrances, including lack of training, limited resources, and opposition towards technological change (Darmawan et al., 2024).

This study attempts to explore to what extent AI-based study material is used in order to optimize deep learning at the primary school levels, focusing on the five dimensions of application of AI-based study material towards optimizing deep learning, knowledge about

AI and deep learning among teachers, application of AI-based material towards optimizing deep learning, impacts on the students, and background, challenges, assistance, and training. The research findings are expected to serve as a pioneer dataset or benchmark for future researchers to determine training needs of educators in developing AI-based teaching resources that further optimize deep learning in education. The aim of this study is to analyze how extensively AI-based teaching materials are adopted to optimize deep learning in elementary schools on five main dimensions: the extent of adoption of AI-based teaching materials to optimize deep learning, the awareness of AI and deep learning among teachers, the extent to which AI-based materials are used to support deep learning, the impact of such materials on learners, and background, challenge, support, and training.

## 2. METHODS

This study employed a quantitative descriptive design with survey research. The reason for this choice was that an effort was needed to have good and proper data regarding the use of AI-based instructional materials by elementary school teachers. Surveys provide authentic answers from the respondents—educators who are the bulk consumers of these materials—and are most appropriate for evaluating perceptions, experience, and satisfaction levels towards teaching materials enhanced with deep learning (Li, 2022; Wang et al., 2021). Survey methodology follows a systematic process, from data analysis to planning. The initial step is having explicit research objectives, for instance, the identification of the research issue and the development of specific research questions (Hsu et al., 2024). Design is engaged in preparing a questionnaire for which validity and reliability are established (Knekta et al., 2019).

### 2.1. Respondent

Target population identification and the selection of a representative sample are crucial in sustaining the validity of survey results. An appropriate sampling method must be employed to ascertain that the sample is indeed representative of the population at large (Kalinowski et al., 2024). A total of 231 teachers from West Java, Indonesia, elementary schools took part as respondents in the current study. The age, gender, education level, and years of teaching experience are the variables describing the characteristics of the respondents. The demographic information is tabulated in Table 1.

**Table 1**. Respondent Demographics

| Information | Total |
|---|---|
| Age | |
| ≤ 25 | 9 |
| 25-34 | 62 |
| 35-44 | 93 |
| 45-54 | 51 |
| ≥ 54 | 16 |
| Gender | |
| Male | 64 |

| Information | Total |
|---|---|
| Female | 167 |
| Educational background | |
| Bachelor | 212 |
| Master | 18 |
| Doctorate | 1 |
| Teaching experience (in years) | |
| ≤ 5 | 24 |
| 5-10 | 52 |
| 11-15 | 50 |
| ≥ 15 | 105 |

Most of the respondents were within the productive age, and 93 respondents were between the ages of 35 to 44. They were women and had a bachelor's degree. Over half of the respondents reported having more than 10 years of experience as educators, which speaks volumes about professional maturity, firm understanding of classroom dynamics, and receptivity to adopting new teaching practices, including the adoption of AI-driven technologies.

### 2.2. Data Collection

Data collection in this study entailed a series of methodical steps to strengthen the validity and usefulness of data gathered. It commenced with the development of a questionnaire containing closed- and open-ended questions based on the research questions (Panjaitan et al., 2021). Once finalized, the questionnaire was administered to the selected sample via the Google Form platform (Iglesias et al., 2024). Once the data had been obtained, there was a preliminary processing process where missing data and incoherence in the responses were ascertained and rectified (Crick, 2024);

### 2.3. Data Analysis

Data analysis in this study commenced with descriptive statistics to characterize the intrinsic structure of data gathered in the form of frequency distributions, mean values, and overall patterns of the data (Crick, 2024). The primary statistical package that was utilized was Microsoft Excel 2024. The final phase involved interpretation of results and the preparation of the research report comprising the key findings, implications, and future study directions (Crick, 2024). This systematic process enabled the researcher to systematically appraise the utilization of AI-based teaching materials and their function in optimizing deep learning. The measurement scale is conceptualized in the following table.

**Table 2.** Classification of AI-Based Teaching Material Utilization for Deep Learning Optimization

| Score Range | Level of Use of AI-Based Teaching Materials for Deep Learning Optimization |
|---|---|
| 0 – 1,00 | Very low |
| 1,01 – 2,00 | Low |
| 2,01 – 3,00 | Enough |
| 3,01 – 4,00 | High |
| 4,01 – 5,00 | Very high |

## 3. RESULTS AND DISCUSSION

### RESULTS

The next section is the discussion of the findings, organized around the a priori research questions. The findings are elaborated in detail in the paragraphs below:

### 3.1 Level of Utilization of AI-Based Teaching Materials for Deep Learning Optimization

This section provides information on the degree to which Artificial Intelligence (AI)-powered teaching tools are used in learning processes towards deep learning. The data provides comparisons of adoption levels of AI among those who have absorbed the technology and those who have not. In order to clearly understand, visualization of data given in graphical form is used to provide comparative trends and perceived usage patterns within the discipline.

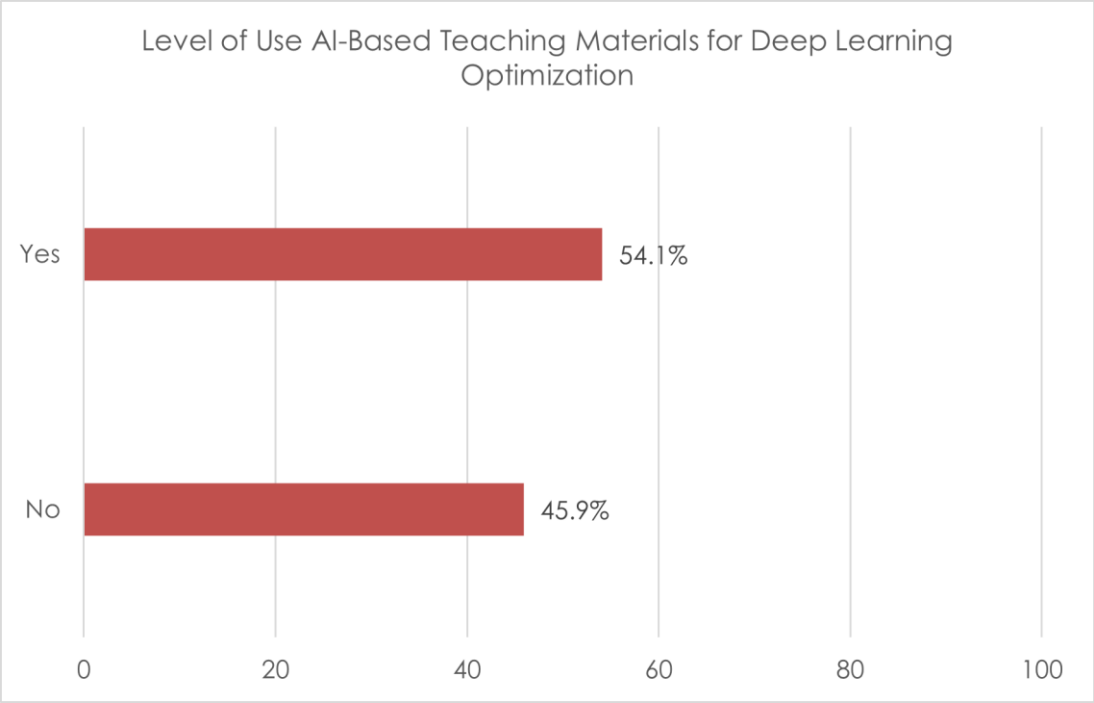


**Figure 1**. Illustration of AI-Based Teaching Material Usage for Deep Learning Optimization

From the graph, the majority of the respondents (54.1%) reported they had used AI-based teaching materials, whereas 45.9% reported that they hadn't used such materials as

yet. Such results show that the utilization of AI technology in the learning process is on the rise, although a high percentage of teachers have not utilized it yet in their teaching practices.

### 3.2 Teachers' Knowledge of AI and Deep Learning

This section provides a comprehensive overview of teachers' average knowledge in the contexts of Artificial Intelligence (AI) and deep learning. It evaluates their familiarity with these concepts and highlights that their awareness and competencies in these fields must be increased.

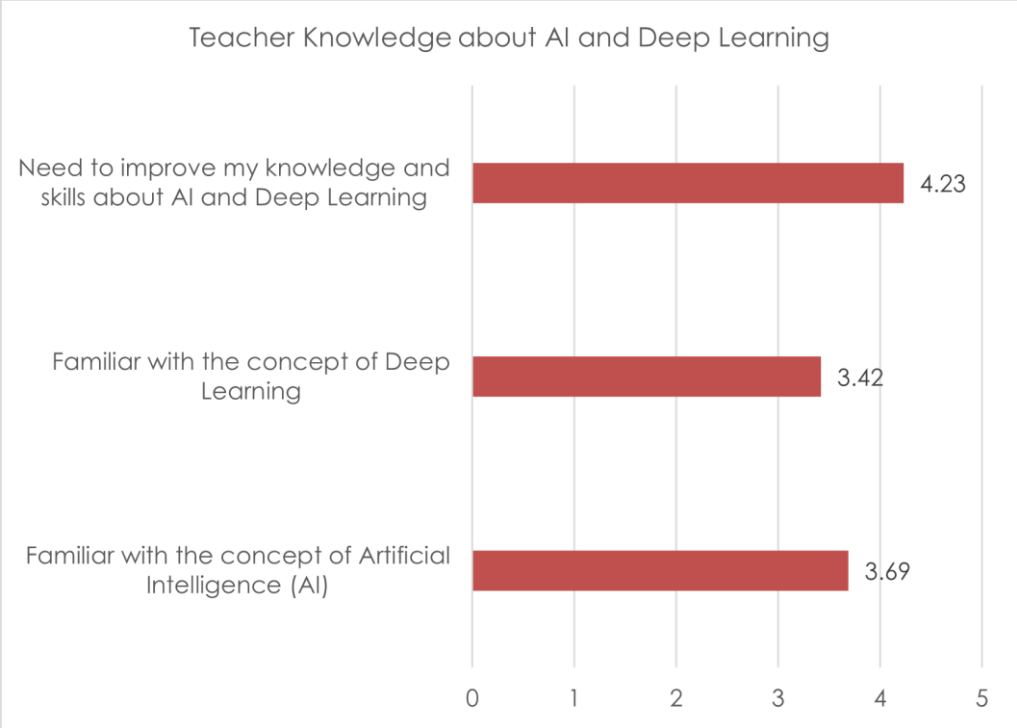


**Figure 2.** Illustration of the Average Teachers' Proficiency in Artificial Intelligence (AI) and Deep Learning.

According to Figure 2, it can be interpreted that teachers' knowledge of AI gets a mean score of 3.69, which shows a moderately high level of understanding. Compared to this, an awareness of the term Deep Learning gets a lower mean score of 3.42, meaning a pretty good awareness but shows the potential for enhancement. Surprisingly, the perceived need for acquiring knowledge and skills in AI and Deep Learning is scored highest at 4.23, indicating a high sense of identification among teachers of the necessity to improve their skills in the said two subjects.

### 3.3 Utilization of AI-Based Teaching Materials to Optimize Deep Learning

The following is an overview of the average application of AI-based teaching materials in supporting deep learning. The figure shows the degree to which the respondents incorporate these materials into their teaching practices. On average, the application of AI tools has started, though the usage level remains diverse. The diversity shows the existence of various readiness and experience levels in embracing technology within the teaching and learning process.

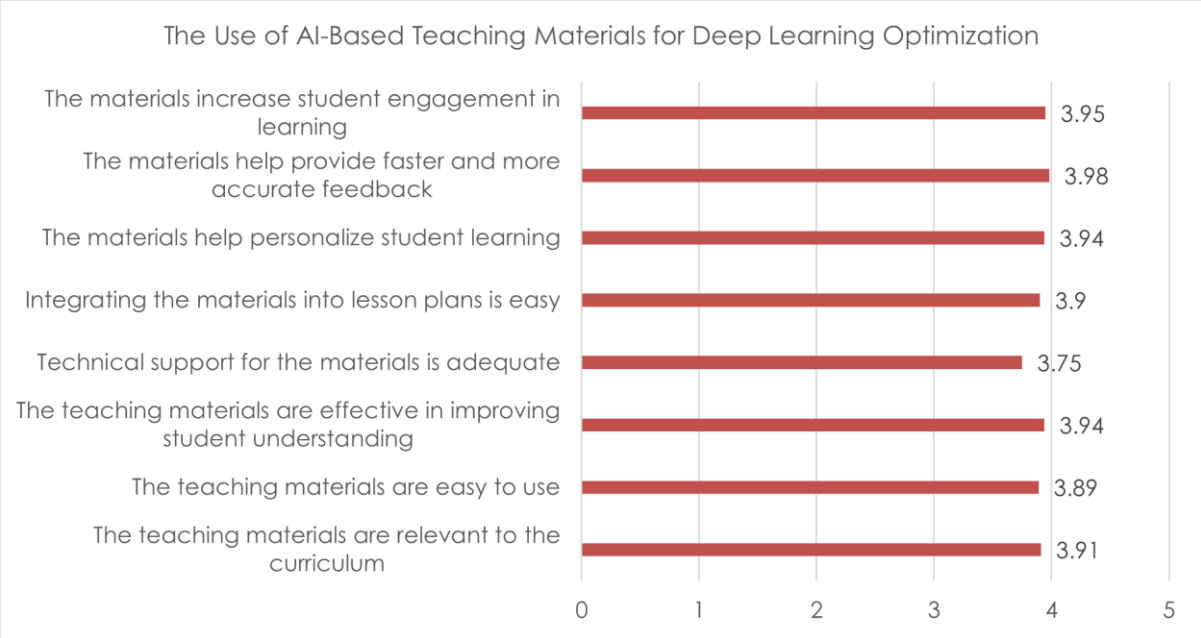


**Figure 3**. Illustration of the Average Utilization of AI-Based Teaching Materials for Optimizing Deep Learning.

Based on Figure 3, the teaching materials were ranked at an average of 3.91, indicating a high overall level of relevance. Ease of use also had an average rating of 3.89, suggesting that ease of use is high overall. Additionally, their capacity to enhance deepening students' understanding and enabling personalized learning both had an average rating of 3.94, an indication of effect on understanding and individualized learning.

Technical support averaged 3.75, which was a bit lower, showing that it is adequate but needs to be improved. The other features that also scored well are integration into lesson plans with an average of 3.9, and to student engagement with an average of 3.95.

Notably, the capability of the materials to provide faster and better feedback received a record high average score of 3.98, indicating the capability of the materials to provide timely and correct feedback. In general, these findings suggest that teachers view AI-based teaching materials as valuable resources for teaching for purposes of facilitating deep learning. Technical support and seamless integration are nonetheless the issues, and these need to be addressed to ensure maximum utilization of AI technology in the teaching learning environment. Nevertheless, challenges such as technical support and seamless integration need to be addressed so as to fully leverage the application of AI technology in learning.

### 3.4 The Impact of AI-Based Teaching Materials on Student Outcomes

The following is a summary of the average ratings of teachers for the impact of AI-based instructional materials on learning. The graph below displays each indicator's effectiveness based on respondents' ratings.

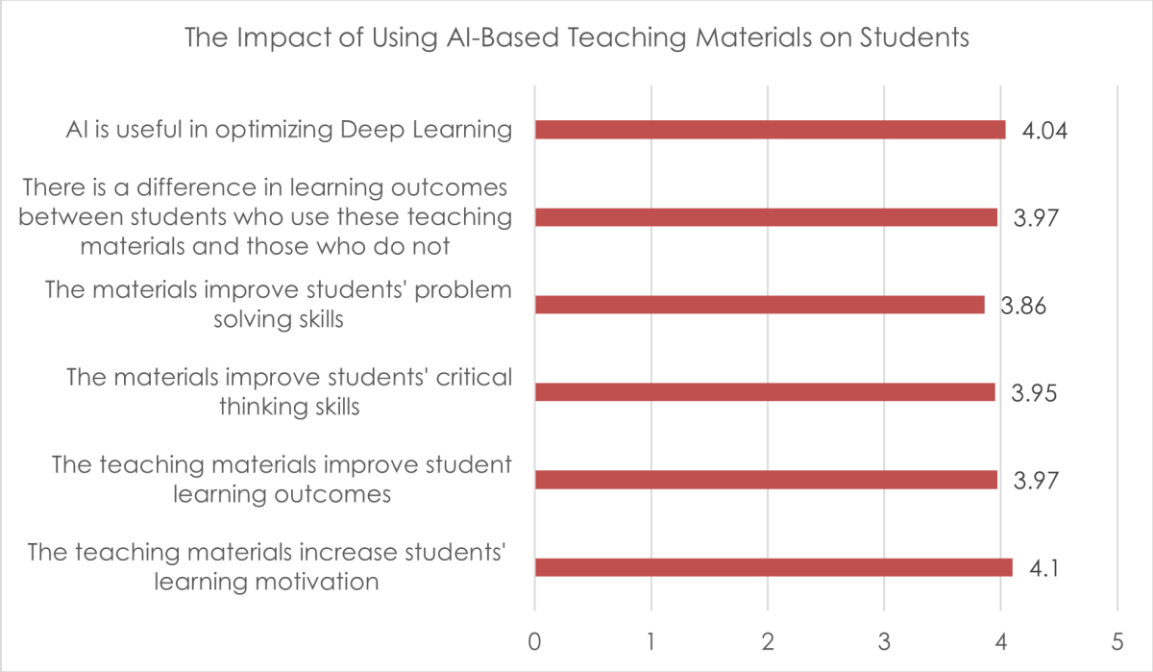


**Figure 4.** Illustration of the Average Impact of AI-Based Teaching Materials on Student Learning.

The result indicates the highest mean score is placed on the use of AI in optimizing deep learning with a score of 4.04. Student learning motivation also earned a very high rating with an average of 4.10, followed by learning outcomes at 3.97. Critical thinking capacity and problem-solving ability were placed on 3.95 and 3.86 respectively. Besides, a statistically significant contrast in the learning performance between the group that employed AI-based instructional materials and the group that did not, in an average score of 3.97, was observed. The findings overall show that teachers perceive AI-based instructional materials to be having a positive effect on various areas of student learning, particularly motivation and deep learning engagement.

### 3.5 Teacher Background, Challenges, Support and Training

To attain a further perspective of the use of AI-based teaching materials in the learning process, teachers' backgrounds, nature of support they attain, challenges they face, and their self-perceived training needs need to be researched.

#### 3.5.1 Rationales for Not Utilizing AI-Based Teaching Materials for Deep Learning Optimization

The following section provides data on teacher backgrounds that have not yet integrated AI-based teaching materials into instruction. The data is categorized according to prevalent reasons in an effort to enhance clarity in the analysis.

**Table 3.** Rationales for Not Utilizing AI-Based Teaching Materials for Deep Learning Optimization

| Category | Example of Respondent Statements | Frequency |
|---|---|---|
| Lack of understanding or mastery of AI | "Not yet understood", "Uneware", "Haven't mastered it", "Still don't understand", etc. | 47 |
| No prior AI training | "Haven't joined training", "Never attended training", "Never been taught", etc. | 18 |
| Limited facilities and infrastructure | "Facilities are not supportive", "Inadequate", "Lack of electronic devices" | 14 |
| AI is not considered relevant to the class context | "Not needed in lower grades", "Not necessary for Grade 3", "Don't know how to use it in PE class" | 9 |
| AI perceived as too complex or technical | "Concept is too complex", "Too much adoption", "Requires a lot of data" | 6 |
| Lack of confidence or personal readiness | "Not confident yet", "Still confused", "Still mixing things up", etc. | 4 |
| Concerns on negative impacts | "Reduces student interaction", "Limits teacher creativity" | 3 |
| Limited time to learn AI | "Time constraints", "Haven't had the chance", etc. | 4 |
| No official teaching materials available | "No materials provided by the government" | 1 |

The data in the Table 3 indicate that the most frequent grounds for avoiding use of AI-based teaching material are lack of knowledge, insufficient proficiency, and lack of exposure to resources or training. There were also apprehensions among a few teachers that excessive use of AI might disrupt direct teacher-student interaction. These findings point towards greater inclusive support and training to enable balanced incorporation of AI into the learning process.

### 3.5.2 Challenges

During the process of applying AI-based teaching materials, educators experience a range of challenges that must be clearly identified. The table below provides an overview of the most significant categories of such challenges as inferred from an analysis of 231 respondent statements.

**Table 4.** Challenges in Using AI-Based Teaching Materials for Deep Leaning Optimization

| Category of Challenges | Example of Respondents' Statements | Frequency |
|---|---|---|
| Limited Infrastructure and Facilities | "School facilities are inadequate," "Technological infrastructure limitations" | 42 |
| Lack of Understanding and Technological (AI/IT) Competence | "Not yet proficient in IT," "Lack of knowledge about AI" | 48 |
| Lack of Training and Literacy for Educators | "Training is still minimal," "Never received any training on AI usage" | 35 |
| Internet Network and Access Issues | "Internet network must be optimal," "Signal and data quota issues" | 22 |
| Students' Difficulty in Understanding AI-Based Learning | "Students do not yet understand AI," "Not all students can immediately grasp AI-based learning" | 28 |
| Concerns About Data Privacy and Security | "Concerned about data privacy," "AI may leak personal information" | 11 |

| Category of Challenges | Example of Respondents' Statements | Frequency |
|---|---|---|
| Complexity of AI and Deep Learning Models | "AI models are hard to understand," "Difficult to explain how AI makes decisions" | 10 |
| Others | "Requires high creativity to design tech-based learning," "Limited time to learn," etc. | 35 |

The Table 4 reveals that the most prominent challenges pertain to limited understanding and technological competence, alongside infrastructural constraints. This underscores the necessity for comprehensive training and the provision of adequate facilities to maximize the effective use of AI in education.

### 3.5.3 Support and Training

To determine the needs and attitudes of teachers towards adopting AI in education, analysis was carried out based on the mean response of both groups of AI users and non-users. Perceived need for training and support in developing AI-based teaching material for both groups is depicted in the Figure 5 below.

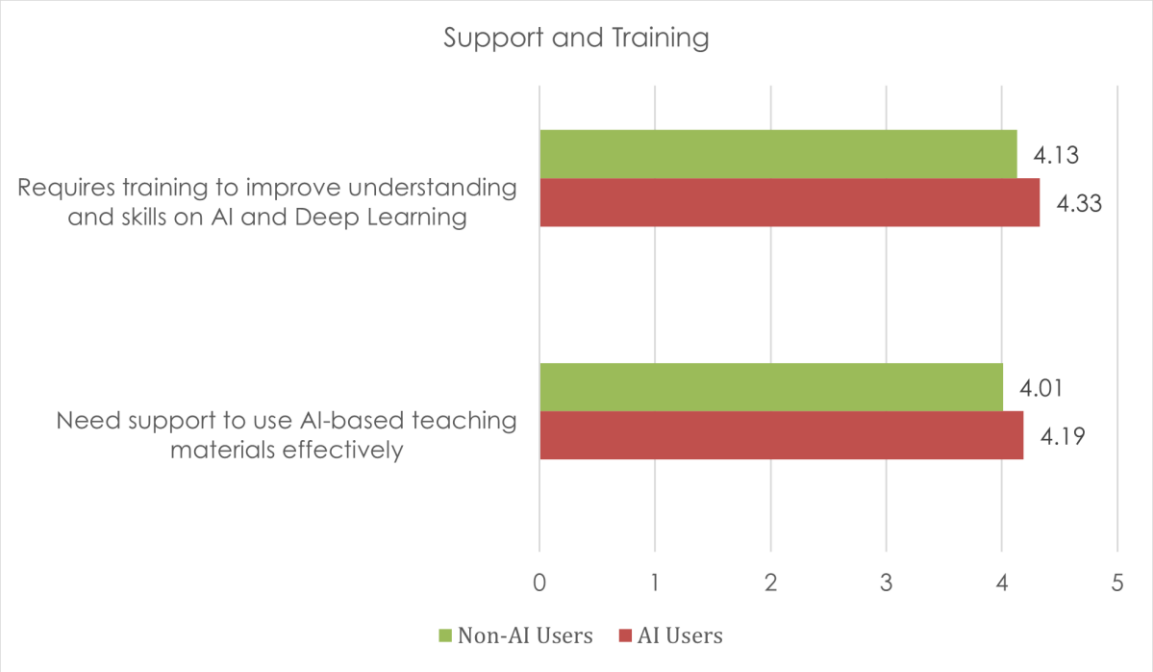


**Figure 5.** Overview of the Need for Support and Training

The data from Figure 5 show that the average requirement for training to acquire AI and Deep Learning increased 4.33 among users of AI and 4.13 among non-users. Similarly, the support requirement for using teaching resources powered by AI also scored 4.19 among users and 4.01 among non-users. These findings identify a high and persistent call for training and assistance in both groups, suggesting continuing need for guidance and capacity development to enable the effective implementation of AI in education. To address this, training needs to be responsive to the needs of teachers, with workshop and practical session solutions preferred by respondents. Further, the sustained focus on infrastructure support points to both teacher and facility proficiency being desirable for the successful integration of AI in schools.

## DISCUSSION

This section provides an interpretation of the results of the research, relating the findings to relevant theoretical frameworks and comparing them with existing studies. The implications of the findings are also to be considered, both for development in an academic context and for practical application within the field.

### 3.6 Level of Use of AI-Based Teaching Materials for Deep Learning Optimization

The use of AI-based teaching materials for the improvement of deep learning has varying levels of utilization among teachers. According to the data, the users and non-users gap is moderate with 53.7% of respondents who had integrated the materials into practice. The difference can be explained in terms of the Technology Acceptance Model (TAM), in which perceived ease of use and perceived usefulness are the drivers (Wicaksono, 2022). These findings corroborate with prior research that indicates, while there are a few teachers who acknowledge the value of technology in education, its implementation still has major hurdles (Salas-Pilco et al., 2022). Computer-based learning instruments are discovered to enhance academic performance, particularly if the users possess high academic ambitions and favorable usage experiences (Kuhn et al., 2022). Therefore, AI implementation in education should concentrate on learning activities that are significant and collaborative to promote perceived usefulness as well as effective technology adoption (Wang & Liu, 2021).

### 3.7 Teachers' Knowledge of AI and Deep Learning

Technological innovation, particularly in Artificial Intelligence (AI), has significantly influenced the educational world. Given its capacity to process information and offer personalized solutions, AI stands to enhance learning efficiency and effectiveness (Waluyo et al., 2024). However, the greatest challenge comes with low levels of skills and knowledge among teachers on how to effectively use AI (Silitonga & Suciati, 2024). This is a clear indication in the research findings, which yield a respondent mean score of 3.69—indicating the need for a greater understanding of AI principles. Hence, stringent training and conducive policy frameworks are required to equip teachers for efficient AI use in classrooms (Fauziddin et al., 2025).

The disparity is even wider in the instance of Deep Learning, with the knowledge mean score of 3.42 revealing that the majority of teachers are still apathetic towards this methodology. One of the causative factors is the lack of training in the pedagogy of Deep Learning (Juarminson, 2025). Deep Learning as a learning model promotes active engagement in which students are not just asked to memorize but to internalize learning in a deep and reflective manner (Atmojo et al., 2025). Deep Learning mindsets can be developed in primary education through targeted professional learning, innovative curriculum planning, and active pedagogies (Khotimah & Abdan, 2025).

### 3.8 Utilization of AI-Based Teaching Materials to Optimize Deep Learning

Research findings suggest that the usage of AI-based instructional materials positively influences the support of deep learning in primary education. Teachers indicated that AI facilitates the availability of diverse information to prepare engaging and needs-based instructional content (Rachmadtullah et al., 2024). Moreover, AI software offers feedback directly, hence the learners can identify and correct errors immediately and enhance their understanding of the content (Syahira et al., 2023). The capacity of AI to personalize learning through adapting instructional methods to individual student characteristics and needs also enables more cognitive engagement (Fauziddin et al., 2025). This technical empowerment enables learning to become a more reflective process and enables higher-order thinking (Sun et al., 2021).

However, for the real empowerment of AI in education, teachers do not just require technical competencies but also corresponding pedagogical competencies so that they can be incorporated appropriately into teaching and learning (Waluyo et al., 2024).

### 3.9 The Impact of Using AI-Based Teaching Materials on Students

Constructivist philosophy perceives learning as an interactive process where students construct knowledge through reflection, social interaction, and discovery on the basis of past experiences, and the teacher acts as a facilitator (Prakash Chand, 2023). Artificial Intelligence (AI) in India is serving as a change agent to empower pedagogy and learning (Bansal, 2023). Correspondingly, AI application within primary education has demonstrated beneficial effects on the learning quality by extending more interactive and creative experiences that effectively heighten the students' motivation (Hapsari et al., 2024). Further, AI supports improved learning outcomes by providing personalized learning, better engagement, as well as adaptive support according to personal needs (Sasikala & Ravichandran, 2024). It also facilitates the development of critical thinking through participatory learning, though its application demands maximum precaution against algorithmic prejudice and AI-based output critical scrutiny (Lawasi et al., 2024).

On implementability, utilizing AI in primary schools necessitates secure and effective measures, particularly in asymmetrical infrastructural environments. Offline-based technologies also provide viable solutions to narrow internet access, whereas active interaction between students and teachers remains essential during the learning process (Restiyanita et al., 2024). The role of teachers in controlling AI incorporation still remains significant, underlining the necessity for digital competency training. Moreover, increasing exposure to AI on the part of teachers and students alike requires policy change along with pedagogic shift. Assignments and instructional approaches must focus on cultivating analysis skills and detailed understanding rather than memorization of information (Ashshiddiqi et al., 2024). Initial exposure to AI is also determined to be one of the methods of avoiding

technological prejudice as well as promoting responsible, thoughtful utilization in the future (Wu et al., 2024).

### 3.10 Teacher Background, Challenges, Support, and Training

One of the key issues of technology adoption by teachers is a lack of adequate resources and restricted digital proficiency (Putri et al., 2022). This is in-agreement with results that indicate users and non-users of AI-based course materials both reporting a high need for support and training. Practical training becomes a necessary component, enabling teachers to gain practical experience and contextual insight. Such training also increases technical skills while creating teamwork in developing and sharing AI-based teaching materials (Waluyo et al., 2024). In Malaysia, the same issues were also identified as fair access, bias algorithm, and a demand for large programs of teacher training. Addressing these demands requires setting ethical standards, investing in ongoing professional learning, and creating inclusive AI tools to serve diverse learner needs (Amdan et al., 2024). Furthermore, there is evidence that teacher education with smart technologies significantly enhances digital literacy and provides personalized, context-relevant learning experiences that fulfill professional growth (Zhai et al., 2024). While doing so, AI incorporation facilitates learners to learn at their own pace and learning style, assists teachers with content design, communication facilitation, and improved assessment techniques (Nuryadin & Marlina, 2023).

## 4. CONCLUSION

Based on the five key dimensions, this study posits that AI-instructed teaching materials contain great potential for optimizing deep learning in primary education despite many emerging challenges. To begin with, in terms of the level of the application of AI, over half the teachers have begun applying the technology, but a majority has not begun to apply it. Second, from the utility viewpoint, teaching content provided by AI is perceived as relevant, accessible, and beneficial to students' knowledge and customized learning but technical support and teacher preparation must be improved. Fourth, the impact on students is largely beneficial, with AI being recorded to increase motivation, learning, and critical thinking—the most significant pillars of the deep learning model. Fifth, the background, challenges, support, and training dimension reveal key challenges such as low awareness levels among teachers, inadequate infrastructure, and resistance to reduced teacher-student contact. Second, most of the teachers are familiar with AI and deep learning, but there is clear potential to be developed further—i.e., the ability to use AI properly and comprehend deep learning theory. Third, from the perspective of practicality, teaching materials provided by AI are widely seen to be relevant, feasible, and helpful for student comprehension and personalized education, but technical support and classroom preparation must be developed further. The users and non-users, however, rate high demand for experiential training and constant support.

Together, these findings offer fertile implications for education stakeholders and policymakers: AI optimization to facilitate deep learning calls for heightened teacher capabilities through in-field training, collaborative development with edtech firms, and hardened infrastructure. Furthermore, this study lays a groundwork for subsequent work to develop professional development programs around innovation in educational technology to drive enhanced quality in primary education.

## 5. ACKNOWLEDGEMENTS

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