FROM TRADITIONAL TO INTELLIGENT LEARNING: DEVELOPMENT OF AI-BASED MATHEMATICS LEARNING MEDIA TO STRENGTHEN DIGITAL LITERACY WITHIN A DEEP LEARNING INSTRUCTIONAL DESIGN FRAMEWORK

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ABSTRACT

IT-based mathematics learning media integrated with AI hold substantial potential in education. However, such media have not been widely implemented in Indonesian schools, particularly at the elementary level. In fact, one of the supporting aspects of the deep learning approach is the use of digital technology, which is closely related to digital literacy as a key 21st-century competency that students must acquire. This study aims to develop interactive mathematics learning media using GeoGebra integrated with AI (ChatGPT) to enhance students' digital literacy and support AI-based deep learning in mathematics, specifically on the topic of the elements and nets of cube and cuboid for grade V elementary students. ChatGPT is use alongside GeoGebra in helping students understand the concepts: GeoGebra facilitated visualization and interactive simulation, while ChatGPT supports conceptual exploration and reflection. This research is a Research and Development (R&D) design using the ADDIE development model. The study was conducted at SD Muhammadiyah 15 Surabaya. The results indicate that the developed media are highly valid, with a validity score of 3.95, and highly practical, with a practicality score of 3.38. In line with the deep learning approach principles: students were able to discover the concepts of elements and nets of cube and cuboid independently and enjoyably through the integration of GeoGebra and ChatGPT (joyful learning). Consequently, the knowledge acquired by the students became meaningful (meaningful learning) and they were able to realize the learning objectives because they were deeply engaged in the process of conceptual discovery (mindful learning).

Keywords: deep learning, instructional design, mathematics learning media, digital literacy

ABSTRAK

Media pembelajaran matematika berbasis IT yang terintegrasi dengan AI memiliki potensi besar dalam pembelajaran, namun media tersebut belum banyak diterapkan di sekolah-sekolah di Indonesia khususnya sekolah dasar. Padahal salah satu aspek pendukung dalam pelaksanaan pendekatan deep learning adalah

pemanfaatan digital yang berhubungan erat dengan literasi digital sebagai kompetensi yang harus dimiliki siswa pada abad ke-21. Penelitian ini bertujuan untuk mengembangkan media pembelajaran matematika interaktif dengan menggunakan GeoGebra yang terintegrasi dengan AI (ChatGPT) yang meningkatkan literasi digital siswa untuk mendukung pembelajaran matematika dengan pendekatan deep learning berbasis AI, khususnya pada materi unsur-unsur dan jaring-jaring kubus dan balok untuk siswa kelas V SD. ChatGPT (AI) digunakan secara bersama-sama dengan GeoGebra dalam proses memahami konsep unsur-unsur dan jaring-jaring kubus dan balok: GeoGebra digunakan untuk visualisasi dan simulasi interaktif, sedangkan ChatGPT digunakan dalam eksplorasi dan refleksi konsep. Penelitian ini merupakan penelitian Research and Development (RnD) dengan model pengembangan ADDIE. Penelitian dilakukan di SD Muhammadiyah 15 Surabaya. Hasil penelitian ini menunjukkan bahwa media yang dikembangkan terbukti sangat valid dengan skor 3.95, serta terbukti sangat praktis dengan skor 3.38. Sebagaimana prinsip pendekatan pembelajaran deep learning: siswa menemukan sendiri konsep unsur-unsur dan jaring-jaring kubus dan balok dengan cara yang menyenangkan melalui keterlibatan teknologi GeoGebra yang terintegrasi dengan ChatGPT dalam pembelajaran (joyful learning), sehingga pengetahuan yang diperoleh siswa bermakna (meaningful learning) dan siswa bisa menyadari tujuan dari pembelajaran yang sedang berlangsung karena siswa terlibat secara mendalam dalam penemuan konsep (mindful learning).

Kata Kunci: *deep learning*, desain pembelajaran, media pembelajaran matematika, literasi digital

A. INTRODUCTION

The development of digital technology and Artificial Intelligence (AI) has brought significant changes to the advancement of education in Indonesia. This transformation requires students to possess 21st-century competencies, one of which is digital literacy. Digital literacy refers to students' ability to access digital learning resources (Yeşilyurt & Vezne, 2023). It can also an essential concept that helps educators and educational administrators understand the demands faced by schools and students in the digital era (Pangrazio, Godhe, & Ledesma, 2020). However, empirical findings from a preliminary study indicate that the use of technology in mathematics learning at schools remains limited. Moreover, the integration of technology in classroom practices has not yet provided adequate opportunities for developing students' critical, analytical, and reflective thinking processes: skills that should be developed through digital-based learning.

On the other hand, mathematics learning in elementary schools is often dominated by traditional instructional

practices that are procedural, repetitive, and focused merely on superficial conceptual mastery (surface learning). To address the mismatch between the 21st-century competency needs of students and the current reality of classroom practices that remain dominated by traditional approaches, the Ministry of Primary and Secondary Education has initiated reforms in the 2025-2026 academic year through the implementation of a deep learning approach in both elementary and secondary education (Tempo, 2024).

However, it has been found that teachers' readiness to implement the deep learning approach remains very limited (Atmojo et al., 2025). In fact, the implementation of deep learning serves as a response to the challenges of fostering 21st-century student competencies, particularly digital literacy. This is because one of the supporting aspects of applying the deep learning approach is the utilization of digital technology in the learning process. The use of digital technology is expected not only to present instructional content but also to provide learning experiences that enable students to understand, apply, and reflect experiences aligned with the learning experiences of deep learning (Suyanto et al., 2025) thereby making learning more adaptive and profound.

In mathematics learning, the integration of digital technology can be realized through the implementation of IT-based instructional media using various software applications, one of which is GeoGebra. GeoGebra is an application that provides interactive visualization of mathematical concepts. The features in GeoGebra that can be used as interactive mathematics learning media and that support the implementation of a deep learning approach include its interactive simulation tools for understanding geometric concepts, particularly the topic of the elements and nets of cube and cuboid for Grade V elementary students. These features can motivate students to become more actively engaged in learning (Sinaga, Setiawan, & Liana, 2022). Moreover, they not only present mathematical concepts directly but also offer students opportunities to independently discover and understand concepts through critical, analytical, and reflective thinking processes (Hidayat, Kamarazan, Nasir, & Ayub, 2023).

Ishartono, et al. (2022) further state that GeoGebra is effective in enhancing students' independent learning.

Furthermore, one of the rapidly developing technologies today is Artificial Intelligence (AI). In the field of education, AI can offer substantial support for both teaching and learning. Therefore, understanding AI mechanisms and applications is essential for teachers (Kim & Kwon, 2023). Previous studies indicate that the use of AI in education can enhance the quality of instruction and improve students' understanding of learning materials, while also providing learning experiences within digital environments (AlAli & Wardat, 2024; Chen, Chen, & Lin, 2020; Pokrivcakova, 2019; Sharma, Kawachi, & Bozkurt, 2019). AI-supported education can also contribute to the achievement of the 2030 Sustainable Development Goals (SDGs) and support the Indonesian government's efforts to strengthen national development in the fields of technology and education as outlined in the fourth of Asta Cita.

Although IT-based mathematics learning media integrated with AI have substantial potential in education, their use in Indonesian schools particularly at the elementary level remains very limited. Mathematics learning media currently used in classrooms are often merely informative and static, lacking interactive and adaptive features necessary to holistically facilitate the deep learning approach. Moreover, no existing studies have integrated IT-based mathematics learning media with AI into the implementation of mathematics instruction using a comprehensive deep learning approach aimed at enhancing students' digital literacy skills. Therefore, this study aims to develop mathematics learning media using GeoGebra integrated with AI (ChatGPT) to improve students' digital literacy and support the successful implementation of mathematics learning design using deep learning approach.

B. Methods

This study employed a Research and Development (R&D) method using Analysis, Design, Development, Implementation, and Evaluation (ADDIE) development model. The research subjects were 20 fifth-grade students from SD Muhammadiyah 15 Surabaya. The data collection

techniques consisted of: (1) observation, which involved monitoring classroom learning activities; (2) questionnaires, which were used to obtain students' responses to the developed media for assessing its practicality; and (3) interviews, conducted with both teachers and students to analyze learning needs related to the implementation of the deep learning approach and to examine student characteristics in relation to digital literacy.

Furthermore, the research instruments consisted of a learning media validation sheet and a student response questionnaire. The data analysis techniques included both quantitative and qualitative analyses. Quantitative data analysis for the validation scores was carried out by calculating the average validation score to determine the feasibility level of the media which was categorized according to Hobri (2021) as presented in Table 1 below.

Table 1 Validity Score Criteria

Average Score ($\bar{x}_v$)	Validity Criteria
$3.25 < \bar{x}_v \leq 4.00$	Highly Valid
$2.50 < \bar{x}_v \leq 3.25$	Valid
$1.75 < \bar{x}_v \leq 2.50$	Less Valid
$0 \leq \bar{x}_v \leq 1.75$	Invalid

The learning media are considered suitable for use if the average validity score falls within the highly valid or valid criteria. Meanwhile, the quantitative analysis of the student response questionnaire was conducted by calculating the average score of students' responses as the practicality score of the media, categorized according to Hasanah, et al. (2023), as presented in Table 2 below.

Table 2 Practicality Score Criteria

Average Score ($\bar{x}_p$)	Practicality Criteria
$3.25 < \bar{x}_v \leq 4.00$	Highly Practical
$2.50 < \bar{x}_v \leq 3.25$	Practical
$1.75 < \bar{x}_v \leq 2.50$	Less Practical
$0 \leq \bar{x}_v \leq 1.75$	Impractical

For the qualitative data analysis, the students' response questionnaires as well as the validators' feedback and comments were examined to inform the revision of the learning media. These findings were analyzed qualitatively to determine how the interactive mathematics learning media developed using GeoGebra integrated with AI (ChatGPT) enhance digital literacy and support the implementation of mathematics learning design using deep learning approach.

C. Results dan Discussion

This research produced an interactive mathematics learning media using GeoGebra integrated with AI (ChatGPT) to enhance students' digital literacy and support the implementation of an AI-based deep learning instructional design in mathematics. The first stage of this study was the analysis stage, which included: analysis of learning needs in schools in relation to the implementation of the deep learning approach, as well as analysis of student characteristics in relation to digital literacy. At this stage, empirical evidence gathered from SD Muhammadiyah 15 Surabaya indicated that mathematics learning rarely utilized IT-based media because such media were perceived as having minimal impact on learning outcomes. Mathematics instruction also had never integrated AI, despite students showing interest in learning media based cutting-edge technology. Furthermore, teachers' understanding of how to holistically implement the deep learning approach by integrating technological tools was found to be very limited.

The second stage was the design stage. In this stage, the interactive mathematics learning media were designed using GeoGebra software for the topic of the elements and nets of cube and cuboid for grade V elementary students. The design process included planning the integration of GeoGebra features for visualizing and simulating interactively the elements and nets of cube and cuboid, integrating AI (ChatGPT) features for conceptual exploration, and developing the storyboard design for the media.

The third stage was the development stage. In this stage, the researchers developed the interactive mathematics learning media using GeoGebra integrated with AI (ChatGPT), and conducted media validation in terms of content, language and symbols, figures and animations, and usability of media. Figure 1 presents the AI-based GeoGebra interactive mathematics learning media for the topic of the elements and nets of cube, while Figure 2 presents the AI-based GeoGebra interactive learning media for the topic of the elements and nets of cuboid.
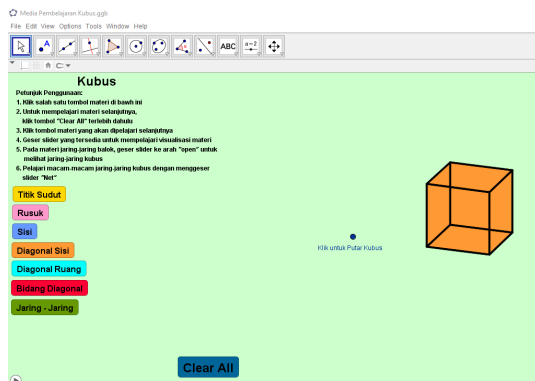
Figure 1 The AI-based GeoGebra interactive mathematics learning media for the topic of the elements and nets of cube
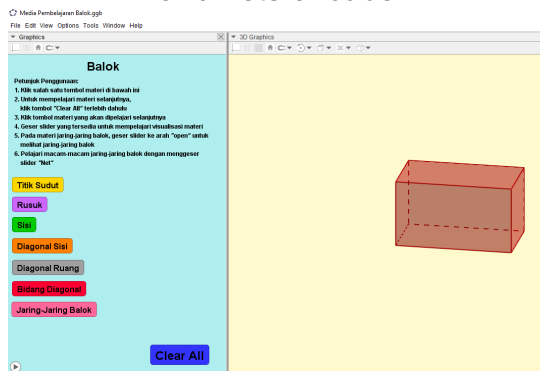

Figure 2 The AI-based GeoGebra interactive mathematics learning media for the topic of the elements and nets of cuboid

The appearances of the developed learning media, as shown in Figure 1 and Figure 2, are presented attractively by using various colors for each object (buttons, cube and cuboid, and background). The visual appearance and design of learning media influence students' motivation to learn (Silwana & Qohar, 2022; Ulyani & Qohar, 2021) and have a positive impact on learners (Borzekowski, 2018). Each button provided in the media is directly

related to the learning content, including buttons for each element of cube and cuboid, as well as buttons for studying their nets. When a button representing an element of a cube or cuboid is clicked, the corresponding types of that element will appear; the same applies to the buttons for cube and cuboid nets. For example, when the "sisi" button is clicked, a slider with 6 sides of cube or cuboid options will appear. Students can move the slider to display any desired sides on the cube or cuboid model shown on the right side of the media.

ChatGPT, as the AI tool integrated into the GeoGebra-based mathematics learning media, was used for conceptual exploration and reflection related to the elements and nets of cube and cuboid. ChatGPT was utilized alongside GeoGebra in the process of understanding these concepts. The ChatGPT features used by students included: (1) an assistant for operating GeoGebra learning media; (2) a trigger for critical thinking through reflective questions and a provider of independent practice exercises; and (3) an interactive question-and-answer assistant. ChatGPT was employed to provide fast feedback according to students'

learning needs (personalized learning) and to make the learning process more interactive by incorporating cutting-edge technology. As reported by Egara & Mosimege (2024), ChatGPT can enhance student engagement and understanding, as well as increase learning effectiveness.

The developed media were validated by media expert. The results of the media validation are presented in Table 3 below.

Table 3 Validity Score Result

Criteria	Average Score
Content Aspect	3.8
Language and Symbols Aspect	4.0
Figures and Animations Aspect	4.0
Usability Aspect	4.0
Validity Score	**3.95**

Based on Table 3, the media validity score obtained was 3.95. Referring to Table 1, this validity score indicates that the developed media falls into the "highly valid" category. Based on the results of the media validation, it can be concluded that the developed media is valid and ready for implementation in the next stage.

At the implementation stage, the developed learning media were tested on 20 fifth-grade students at SD

Muhammadiyah 15 Surabaya through a mathematics learning session on the topic of the elements and nets of cube and cuboid. After the trial, students completed a students' response questionnaire regarding the media, focusing on the aspects of material presentation as well as language and visual appearance of media. The results of the student response questionnaire are presented in Table 4 below.

Table 4 Practicality Score Result

Criteria	Average Score
Material Presentation Aspect	
Media is easy to use	3.60
Media helps students understand mathematics material	3.45
Media is able to make students enjoy mathematics	3.10
Media is able to make students active in learning mathematics	3.20
Language and Visual Appearance Aspect	
Instruction and information in the media are easy to understand	3.40
Media display is attractive	3.55
Practicality Score	**3.38**

Based on Table 4, the practicality score obtained was 3.38. Referring to Table 2, this score indicates that the developed media has a high level of practicality or is considered very practical. The results of the student response questionnaire also show that

students gave positive responses to the developed media, and they became more active during the mathematics learning process because they were highly enthusiastic about learning mathematics using new technology (GeoGebra and AI), which they had never known or used before.

Next, in the fifth stage, evaluation, revisions of media developed were made to the media using GeoGebra integrated with AI (ChatGPT) for the topic of the elements and nets of cube and cuboid. The refinements of media were carried out by revising the learning media based on the validators' revision notes and comments, as well as the results of the media trial. Based on the validation results and student response questionnaires, the researches made revisions and improvements to the learning media, particularly on aspects that created ambiguity in students' concept understanding.

After completing the five development stages. The interactive mathematics learning media using GeoGera integrated with AI (ChatGPT), which enhances students' digital literacy, was proven to be highly valid and highly practical for use in mathematics learning with an AI-based deep learning approach. This learning media aligns with the principles of deep learning, namely mindful learning, meaningful learning, and joyful learning. The media does not present material for students to understand directly; instead, students discover the concepts themselves in an enjoyable way through the integration of GeoGebra and ChatGPT, which technologies that students rarely use in learning (joyful learning). As a result, the knowledge they acquire becomes meaningful (meaningful learning), and students can clearly recognize the purpose of the learning process because they are deeply engaged in concept discovery (mindful learning). Chiu et al (2023) stated that the use of AI in mathematics learning media provides a new experience for students, serving as a strong point of attraction and enhancing student interactivity within digital learning environment. So that it can enhance students' digital literacy.

Furthermore, the interactive mathematics learning media developed using GeoGebra provide clear and interactive visualizations of cube and cuboid to support students' discovery of their elements and nets of

cube and cuboid. Saputra & Fahrizal (2019) state that GeoGebra is an appropriate and effective application for use as learning media. Learning technologies become effective when they are able to increase student engagement and support the achievement of deep learning objectives (Fullan & Langworthy, 2013). GeoGebra has also been shown to be effective in mathematics instruction (Nzaramyimana, Mukandayambaje, Iyamuremye, & Hakizumuremyi, 2021) and in improving students' mathematical abilities (Juandi, Kusumah, Tamur, Perbowo, & Wijaya, 2021). In addition, the effective integration of digital technology serves as a critical supporting factor in the implementation of deep learning approaches (Suyanto et al., 2025).

The integration of AI, specifically ChatGPT, into the GeoGebra-based interactive mathematics learning media enables a more adaptive learning experience. AI can serve as a tool that supports students in learning independently (Nisar & Aslam, 2023) and can also enhance the effectiveness and efficiency of the teaching (Murphy, 2019). Findings from this study reveal that students demonstrated creativity in generating prompts for ChatGPT, indicating that the integration of AI also contributes to developing students' creative thinking skills in exploring information. This aligns with Kasneci et al. (2023) who state that AI can offer a wide range of learning experiences for students.

The advantages of the developed learning media are as follows: (1) the media display and features have an attractive interface with a design according to fifth-grade elementary school students; (2) it supports the implementation of a deep learning approach in mathematics instruction by providing opportunities for students to learn independently and discover concepts on their own through the three principles of deep learning (mindful learning, meaningful learning, and joyful learning); and (3) it enables students to gain new learning experiences in an engaging and interactive digital environment so that it can enhance students' digital literacy. However, based on the evaluation conducted during the media trial, this learning media also has a limitation, namely the need for guidance for elementary school students who are not yet familiar with operating GeoGebra and ChatGPT.

E. Conclusion

The interactive mathematics learning media on the topic of the elements and nets of cube and cuboid, developed using GeoGebra integrated with AI (ChatGPT), was proven to be highly valid with a score of 3.95 and highly practical with a score of 3.38 for use in mathematics learning design of AI-based deep learning approach. GeoGebra was utilized to provide visualization and interactive simulations of the elements and nets of cube and cuboid, while ChatGPT, integrated into the GeoGebra-based learning media, supported students in concept exploration and reflection. ChatGPT was used alongside GeoGebra to help students understand the concepts of the elements and nets of cube and cuboid.

The learning media aligns with the core principles of deep learning approach: mindful learning, meaningful learning, and joyful learning. Students were able to discover the concepts independently and engage in enjoyable learning experiences through the integration of GeoGebra and ChatGPT, which they had rarely or never used before (joyful learning). This process enabled students to construct meaningful knowledge (meaningful learning) and develop awareness of the learning objectives as they were deeply involved in the conceptual discovery process (mindful learning).

For future research, follow-up studies may explore the application of the learning media to other mathematics topics or integrate different software and AI tools to further enhance mathematics learning.

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