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Improving the Skills of Junior High School Mathematics Teachers in Developing Deep Learning-Oriented Lesson Plans Using ChatGPT

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Abstract Advances in artificial intelligence (AI) offer new opportunities for creating more adaptive and engaging learning experiences in schools. However, many mathematics teachers, particularly in developing regions, still face challenges in integrating AI tools into instructional design due to limited AI literacy and access to professional development. This study aimed to improve junior high school mathematics teachers' competence in developing deep learning–oriented lesson plans (in the pedagogical sense of meaningful and reflective learning, not AI algorithms) using ChatGPT. This study employed a descriptive quantitative design complemented by qualitative evaluation. Thirty teachers participated in AI-assisted training, mentoring, and collaborative lesson planning activities. Data were collected through pretest–posttest assessments and rubric-based evaluations of lesson plan products. Results showed a substantial improvement in teachers' understanding, with the average score increasing from 59.17 to 82.83 (+23.66 points). Approximately 90% of teacher groups successfully integrated deep learning characteristics, and 83% effectively utilized ChatGPT to design contextual and higher-order thinking tasks. These findings indicate that structured AI-based professional development can enhance teachers' pedagogical competence and instructional creativity. This study contributes a practical model for integrating generative AI into teacher professional development and supports the implementation of the Merdeka Curriculum through AI-assisted instructional design.

INTRODUCTION

The rapid advancement of artificial intelligence (AI) is transforming many aspects of modern life, including education. AI-based tools such as ChatGPT offer new opportunities for teachers to design more adaptive, engaging, and personalized learning experiences. These technologies can assist educators in generating instructional materials, providing feedback, and supporting differentiated learning. However, despite their potential, the integration of AI into everyday teaching practices remains challenging, particularly in developing regions where teachers often have limited AI literacy and restricted access to technology-based professional development (Almusharraf & Almusharraf, 2021; Ahmad et al., 2022).

In Indonesia, these challenges are also evident at the secondary school level. Mojokerto Regency in East Java has over 100 junior high schools with hundreds of mathematics teachers responsible for strengthening students' STEM competencies. Nevertheless, mathematics achievement remains relatively low compared to other subjects, as indicated

by local examination reports (Dinas Pendidikan Kabupaten Mojokerto, 2023). Improving instructional quality and teacher capacity is therefore essential to enhance students' mathematical understanding and learning outcomes.

Several barriers hinder the effective adoption of AI in mathematics education. Previous studies report that many teachers demonstrate limited knowledge of AI technologies, experience high workloads, lack access to relevant professional development, and face digital infrastructure constraints (Zhang & Yin, 2023; Oktavia & Putri, 2022; Wahyuni & Saputra, 2021; UNESCO, 2021). Although generative AI tools such as ChatGPT have been shown to support higher-order thinking and instructional creativity by helping teachers design contextual problems and varied learning activities (Kasneci et al., 2023; Holmes et al., 2022), their pedagogical use in lesson planning is still not widely understood.

From a pedagogical perspective, this study adopts the concept of deep learning in the educational sense—referring to meaningful, reflective, and conceptually rich learning rather than AI algorithms. Deep learning emphasizes connections to prior knowledge, collaboration, critical thinking, and real-life application (Biggs & Tang, 2007; Smith & MacGregor, 1992). Generative AI tools like ChatGPT can potentially support these principles by assisting teachers in producing contextual tasks, multiple representations, and reflective prompts that encourage students' metacognitive engagement.

These pedagogical shifts align with Indonesia's Merdeka Curriculum, which promotes student-centered, project-based, and contextual learning approaches (Kementerian Pendidikan dan Kebudayaan Republik Indonesia, 2022; OECD, 2020). However, classroom practices in many schools, including those in Mojokerto, still tend to rely on conventional and worksheet-driven instruction (Fatimah & Raharjo, 2023). This mismatch highlights the need for professional development programs that help teachers integrate innovative technologies with curriculum expectations.

Although research has discussed AI integration and teacher professional development in general, empirical evidence on AI-assisted lesson planning training for mathematics teachers—particularly in regional Indonesian contexts—remains limited. Few studies have systematically examined how generative AI tools such as ChatGPT can enhance teachers' competence in designing deep learning–oriented lesson plans and improve instructional quality. Consequently, there is a need for research that evaluates the effectiveness of structured AI-based training interventions for mathematics teachers.

To address this gap, a professional development program was implemented to train junior high school mathematics teachers to use ChatGPT in designing deep learning–oriented lesson plans. The program provided AI literacy training, hands-on workshops, collaborative mentoring, and curriculum-aligned instructional design support. Therefore, this study aims to evaluate the effectiveness of the ChatGPT-assisted training program in improving teachers' understanding and competence. Specifically, the study investigates (1) changes in teachers' knowledge following the training and (2) the quality of lesson plans developed using AI assistance. This study contributes a practical and contextually relevant

model for integrating generative AI into teacher professional development and offers empirical evidence to support AI-assisted instructional design in mathematics education.

METHOD

This study employed a quantitative descriptive design using a one-group pretest–posttest approach through the implementation of a structured teacher training program focused on integrating artificial intelligence, particularly ChatGPT, into the development of deep learning–oriented mathematics lesson plans. The program was conducted as part of a community service initiative in Mojokerto Regency, East Java, and involved 30 junior high school mathematics teachers from public and private schools. Participants were recruited through coordination with local education stakeholders and voluntarily agreed to participate. All teachers were actively teaching mathematics and attended both offline and online sessions. As no control group was included, the results are interpreted as practical improvements rather than causal comparisons.

The program consisted of three stages: preparation, implementation, and evaluation. During the preparation stage, the research team identified training needs and developed instructional modules covering AI literacy, the pedagogical use of ChatGPT, deep learning principles, and lesson planning aligned with the Merdeka Curriculum. Supporting materials included presentation slides, worksheets, sample lesson plans, and assessment instruments. Communication and coordination with participants were facilitated through a dedicated WhatsApp group.

The implementation stage adopted a blended learning format combining face-to-face workshops and online mentoring. Teachers participated in introductory sessions on AI in education, demonstrations of ChatGPT-assisted lesson design, and guided practice in generating learning objectives, contextual problems, and project-based activities. Participants then worked collaboratively in small groups to design mathematics lesson plans using ChatGPT, while facilitators provided feedback to ensure that AI-generated content was pedagogically appropriate and aligned with curriculum standards.

Evaluation was conducted through both individual and group assessments. Individually, teachers completed a pretest and posttest to measure changes in their understanding of AI literacy, deep learning concepts, and AI-assisted instructional design. The test items were developed based on the training objectives and reviewed by two experts in mathematics education to ensure content validity. In groups, participants submitted a complete lesson plan and presented their instructional designs.

To ensure a valid and structured evaluation, the lesson plans were assessed using an analytic rubric that included the following four indicators:

1. Clarity and Accuracy of Learning Objectives and Indicators: The degree to which learning objectives are clearly stated, measurable, and aligned with expected deep learning outcomes such as higher order thinking and conceptual understanding.
2. Integration of Deep Learning Characteristics: The extent to which the lesson incorporates key features of deep learning, including connections to prior

knowledge, real-life context, student collaboration, reflective activities, and application of knowledge.

3. Effective and Ethical Use of ChatGPT: The appropriateness and creativity of using ChatGPT to support instructional design, including the accuracy of AI-generated content, its relevance to lesson goals, and the teacher's ability to adapt and refine the material responsibly.
4. Alignment with the *Merdeka Curriculum*: The consistency of the lesson plan with the structure, principles, and expected competencies outlined in the *Merdeka Curriculum*, particularly in terms of student-centered and project-based learning.

Each indicator was rated using a 4-point Likert scale:

- 1 = Not Evident
- 2 = Emerging
- 3 = Proficient
- 4 = Exemplary

Group scores (maximum 16 points) were categorized into four levels:

- 13–16: Very Good
- 9–12: Good
- 5–8: Fair
- 1–4: Poor

All data—including pretest and posttest results and final product evaluations—were analyzed descriptively to assess the effectiveness of the training program and the improvement of teachers' pedagogical competence in integrating ChatGPT and AI-based tools into mathematics instruction.

All participants provided informed consent, and the data were collected anonymously for research purposes.

RESULT AND DISCUSSION

The implementation of the ChatGPT-assisted lesson planning training program led to observable improvements in both teachers' conceptual understanding and their instructional design practices. At the beginning of the program, many participants were unfamiliar with the pedagogical use of generative artificial intelligence tools, particularly ChatGPT, to support lesson planning. Most teachers relied on conventional approaches and had limited confidence in integrating AI into their preparation process. As the workshops and mentoring sessions progressed, however, teachers gradually became more comfortable using ChatGPT to formulate learning objectives, generate contextual mathematical problems, and design collaborative learning activities aligned with deep learning principles and the Merdeka Curriculum.

These changes were reflected in the pretest–posttest results. The average pretest score was 59.17, indicating a moderate baseline level of understanding. After the training, the average posttest score increased to 82.83, resulting in a gain of 23.66 points. This improvement suggests that the combination of theoretical explanation, guided practice, and

collaborative mentoring helped strengthen teachers' knowledge of AI literacy, deep learning concepts, and AI-assisted instructional design. The results indicate meaningful learning gains associated with the intervention.

In addition to cognitive improvement, the quality of the lesson plans developed by the participants also showed clear progress. Based on the analytic rubric, most teacher groups were able to integrate essential characteristics of deep learning into their lesson designs. Many plans connected mathematical concepts to students' prior knowledge and real-life contexts, promoted collaboration, and included reflective activities that supported conceptual understanding. Teachers also demonstrated purposeful and appropriate use of ChatGPT to develop varied tasks and higher-order thinking problems. Overall, the majority of lesson plans were categorized as good to very good, indicating satisfactory instructional quality.

To illustrate these instructional improvements more concretely, several lesson plans produced during the training demonstrated clear alignment with deep learning principles. For example, one group formulated the following learning objective:

"Siswa mampu menyelesaikan permasalahan sehari-hari yang dapat dimodelkan dengan persamaan linear satu variabel melalui diskusi kelompok dan presentasi hasil kerja" (*Students are able to solve real-life problems modeled using linear equations through group discussion and presentation of their work*.)

This objective emphasizes collaboration, contextual application, and conceptual understanding rather than procedural memorization. Teachers also used ChatGPT to generate contextual story problems connected to everyday situations, such as:

"Seorang pedagang membeli 4 kotak pensil dan 3 penghapus seharga Rp28.000, sedangkan pembelian 2 kotak pensil dan 1 penghapus seharga Rp14.000. Tentukan harga satu kotak pensil dan satu penghapus." (*A shopkeeper buys four boxes of pencils and three erasers for Rp28,000, while two boxes of pencils and one eraser cost Rp14,000. Determine the price of one box of pencils and one eraser*.)

In addition, some lesson plans included reflective prompts, for instance:

"Bagaimana cara kamu menghubungkan konsep persamaan dengan kegiatan sehari-hari di rumah atau di sekolah? Berikan contohnya." (*How can you relate the concept of equations to your daily activities at home or school? Give examples.*)

Such tasks encouraged students to connect mathematical ideas with personal experiences and supported metacognitive thinking, which are key elements of deep learning.

A summary of the quantitative outcomes is presented in Table 1.

Table 1. Summary of Pretest–Posttest and Lesson Plan Evaluation Results

Evaluation Component	Indicator	Result
Cognitive Competence (n = 30)	Mean Pretest Score	59.17
	Mean Posttest Score	82.83
	Gain Score	+23.66

Lesson Plan Quality (Group Evaluation)	Integration of deep learning characteristics	90%
	Contextual and collaborative tasks	86%
	Effective use of ChatGPT	83%
	Creativity and curriculum alignment	80%

For ease of comparison, these outcomes are also illustrated in Figure 1, which visually summarizes both cognitive and instructional improvements

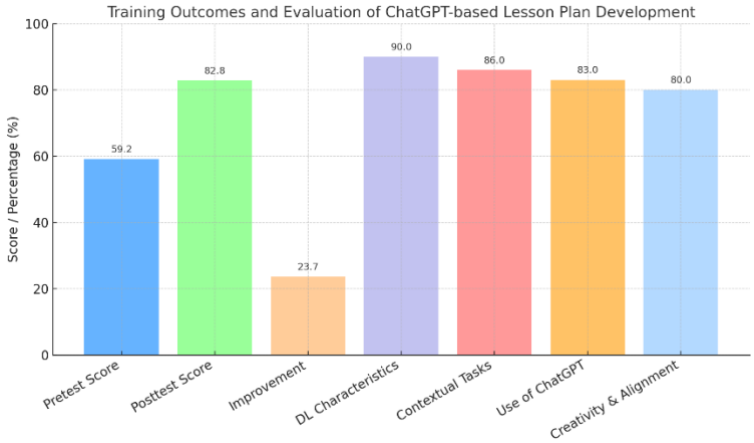

Figure 1. Training Outcomes and Evaluation Results

The findings are consistent with established perspectives on effective teacher professional development. Research suggests that professional learning is most impactful when it combines theoretical input, collaborative practice, and sustained mentoring (Desimone, 2009; Tondeur et al., 2021). The structure of the present training reflects these principles, as teachers were not only introduced to AI concepts but also given opportunities to apply them directly in authentic lesson design tasks. From a pedagogical perspective, the resulting lesson plans reflect the characteristics of deep learning, including critical thinking, reflection, and contextual application (Biggs & Tang, 2007). Recent studies have similarly reported that generative AI tools can enhance teachers' creativity and efficiency when used as instructional design supports rather than replacements for professional judgment (Kasneci et al., 2023; Cotton et al., 2023). The present results reinforce these findings within the context of Indonesian mathematics education.

Teachers' feedback further supported these results. Many participants reported that ChatGPT reduced preparation time, provided diverse examples of problems, and inspired new ideas for classroom activities. At the same time, several challenges were noted, including unstable internet access and the need to carefully review AI-generated content for contextual accuracy. These experiences indicate that AI tools function best as supportive resources that complement, rather than replace, teachers' expertise.

Several limitations should be considered when interpreting the findings. The study involved a relatively small sample and employed a one-group pretest–posttest design without a comparison group, which limits causal generalization. The analysis relied primarily on descriptive statistics. Future studies may involve larger samples, comparative designs, or inferential analyses to provide stronger empirical evidence regarding the effectiveness of AI-assisted professional development.

The findings of this study indicate that integrating generative AI into teacher professional development is both feasible and beneficial. The training model offers a practical approach for supporting mathematics teachers in designing deep learning–oriented lesson plans and may be adapted by other schools or regions facing similar challenges in technology integration.

CONCLUSION AND SUGGESTIONS

This study indicates that integrating ChatGPT into lesson plan development can support improvements in junior high school mathematics teachers' pedagogical competence. Through a structured professional development program that combined theoretical sessions, hands-on workshops, and collaborative mentoring, teachers strengthened their understanding of deep learning principles and learned how to use generative AI tools more purposefully in instructional design. Improvements were reflected in both the increase in pretest–posttest scores and the enhanced quality of lesson plans, which demonstrated stronger contextualization, collaboration, creativity, and alignment with the Merdeka Curriculum.

Most participants were able to incorporate ChatGPT effectively into their planning process, using it to formulate learning objectives, design contextual problems, and develop activities that encourage higher-order thinking. Although some teachers initially experienced difficulties, particularly related to unfamiliarity with AI tools and limited internet access, they gradually showed adaptability and confidence in applying new technologies. The use of online communication and mentoring platforms also supported collaboration and continuous feedback throughout the training.

These findings suggest that AI-assisted professional development can serve as a practical and feasible approach to strengthening teacher capacity, particularly in contexts where support for instructional innovation is still limited. The training model presented in this study offers a realistic framework that may be adopted or adapted by other schools and regions seeking to integrate AI literacy with curriculum implementation. Nevertheless, the study was conducted with a relatively small sample and employed a one-group design, so the results should be interpreted as indications of practical improvement within this context rather than broad causal claims.

To sustain and expand the impact of this initiative, future programs should provide continuous mentoring, improve access to reliable digital infrastructure, and encourage ongoing teacher collaboration. Further research is recommended to involve larger samples, comparative designs, or longitudinal approaches to examine how AI-assisted lesson planning influences classroom practices and student learning outcomes over time. Such efforts will help determine the long-term effectiveness and scalability of integrating generative AI tools like ChatGPT into mathematics education.

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