
The Effectiveness of Using AI-Based Chatbots as Virtual Assistants in Programming Learning For Junior High School Students

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Abstract: This study aims to measure the effectiveness of using Artificial Intelligence (AI)-based chatbots as virtual assistants in programming learning at SMP. The research method employed was a quasi-experimental design with a pretest-posttest control group. The experimental group used AI-based chatbots, while the control group followed conventional learning. The results showed a significant improvement in the learning outcomes of students in the experimental group compared to the control group. Students' perceptions of chatbot usage also indicated positive responses, particularly in ease of use, learning motivation, and clarity of feedback. The use of chatbots effectively increased student engagement and facilitated adaptive independent learning. Therefore, AI-based chatbots are proven to be an innovative solution to support programming learning in junior high schools. This study contributes to the development of digital learning media relevant to the needs of digital native students.

Keywords: Chatbot, Artificial Intelligence, Programming Learning, Learning Outcomes, Junior High School Students.

INTRODUCTION

The development of artificial intelligence (AI) technology has driven significant changes in various sectors, including education. At the international level, the application of AI in education is becoming more widespread, focusing on improving learning personalization and teacher efficiency in delivering materials (Arisanti et al., 2024). One form of AI application that is developing is the use of chatbots as virtual assistants to help the teaching and learning process. Well-designed chatbots can provide an interactive, responsive, and supportive learning experience for students (Arwan, 2024). In Indonesia, the digitalization of learning has begun to be directed at the integration of AI-based technology as a form of adaptation to the Industrial Revolution 4.0 and Society 5.0. The government, through the Independent Curriculum, has also provided space for schools to develop a more flexible and contextual technology-based learning model (Sitorus & Murti, 2024). This shows the urgency to examine the use of AI in a more focused manner in the context of national education.

The phenomenon of the digital literacy gap and the computational thinking ability of

Indonesian students has been highlighted in various international studies. Based on the results of the Programme for International Student Assessment (PISA) in 2018, Indonesia's score in terms of digital literacy and technology-based problem solving is still below the OECD average (Munsarif & Safuan, 2025). This condition is exacerbated by the limited availability of contextual learning resources and the lack of interactive media in suburban schools, including in eastern Indonesia. On the other hand, students of the digital native generation show a high interest in technology-based learning, including media that resembles social interactions, such as chatbots (Sinaga, 2024). Research shows that the use of chatbots can increase student engagement in learning as well as help explain difficult concepts gradually and communicatively (Sabariah et al., 2024). Therefore, the use of chatbots as virtual assistants needs to be further explored as a solution to overcome learning challenges in the digital era. This approach is believed to bridge the gap between teachers' limitations and students' independent learning needs.

The assumption of solutions to the low effectiveness of programming learning at the junior high school level can be traced to a

learning approach that is not adaptive to the needs of students. Learning programming is often considered difficult because the approach is still lecture-based and has minimal interaction, even though junior high school students need visual and interactive stimuli that suit their learning style (Alamin & Missouri, 2023). Previous research has found that the use of chatbots in basic coding learning can improve understanding of algorithm concepts and programming logic (Tribethran et al, 2023). AI-based chatbots can provide instant and adaptive feedback on mistakes made by students, thereby accelerating the process of understanding and strengthening retention. In addition, chatbots also allow learning to take place outside of classroom hours without full dependence on teachers (Sugiyarto et al, 2025). Thus, the use of chatbots not only serves as an auxiliary medium but also as an intelligent and flexible learning facilitator. This is an approach that is in line with the principles of Independent Learning and differentiated learning.

The integration of chatbots in programming learning is also considered to be in line with 21st-century competencies that emphasize critical thinking, creativity, collaboration, and digital literacy skills. Research proves that the use of interactive chatbots in elementary education can increase students' interest in learning, intrinsic motivation, and courage in trying to solve programming-based problems (Diasri et al, 2025). Apart from being a learning tool, chatbots also act as learning companions that can adjust responses to student needs through NLP (Natural Language Processing) technology. This allows students to learn in a non-intimidating atmosphere, so they are freer to ask questions and explore concepts. In schools with minimal access to informatics teachers, chatbots can answer students' questions independently and direct them to the correct logical stages. This advantage is what makes chatbots potentially integrated into informatics learning in junior high schools, especially in basic programming materials. What's more, in the context of education in areas such as Lambu District, the use of chatbots can help equalize access to digital learning.

Based on the above background, it can be identified that the main problem in learning programming at SMP Negeri 2 Lambu is the limited interactive learning media, which follows the characteristics of students and geographical

challenges. Learning that is still conventional is less able to answer the needs of digital generation students in understanding programming logic. In addition, the limited resources of informatics teachers and the lack of optimal use of AI technology are the main obstacles. Therefore, it is necessary to study the effectiveness of using AI-based chatbots as virtual assistants that can assist students in learning programming independently and adaptively. This research is directed to answer whether the use of chatbots can improve student learning outcomes in programming materials and provide a more enjoyable and meaningful learning experience. The results of this research are expected to contribute to the development of contextual and applicative digital learning media at the junior high school level. Thus, this article aims to measure the effectiveness of AI chatbots in improving learning outcomes and the quality of the programming learning process at SMP Negeri 2 Lambu.

METHODS

This research is based on a quasi-experimental approach with a pretest-posttest control group design, which aims to measure the effectiveness of using AI-based chatbots in programming learning for junior high school students. This approach was chosen because it allowed researchers to observe differences in learning outcomes between the experimental group (using a chatbot) and the control group (without a chatbot) under almost equal conditions (Hadian & Rahmi, 2023). The use of chatbots in education has been shown to increase learning effectiveness and student engagement in previous studies (Pustikayasa et al, 2023; Satar et al, 2025). Chatbots are also considered effective in improving cognitive learning outcomes in basic programming materials because they can present instant feedback and adaptive questions (Hasman et al, 2023; Pradita et al, 2025). Therefore, Vygotsky's theory of social constructivism is used as a conceptual basis, where chatbots function as scaffolding or interactive companions that facilitate the development of the student's proximal zone (ZPD) (Novitasari et al., 2024). Other studies have also shown that AI technologies such as chatbots can help students think computationally gradually and personally (Herabadi, 2025; Ririh et al, 2020).

Relevant empirical studies support the use of chatbots in various levels of education, including primary and secondary schools. For example, research shows that educational chatbots can improve students' understanding of concepts and collaboration in STEM subjects (Aini et al., 2024). At the junior high school level, research underscores that AI-based learning media such as chatbots can overcome teachers' time constraints in providing individual guidance (Nurhayati et al, 2024; Andreana et al, 2024). Furthermore, studies prove that chatbots can help increase learning motivation and information retention among early childhood students (Abdullah & Sudirman, 2025). In the context of Indonesian education, studies show that Indonesian-based chatbots are effective in delivering text- and block-based programming learning content (Adnyana et al., 2025). Research adds that chatbots can lower students' anxiety when learning to code due to their communicative and non-judgmental nature (Abdullah et al., 2025). By referring to these studies, this research is expected to be able to contribute to the development of innovative learning models in junior high schools, especially those in areas with limited access to informatics teachers, such as SMP Negeri 2 Lambu.

This research is carried out through several systematic stages that follow the principles of needs-based development and scientific approaches. The first stage is pre-research, which is carried out by conducting a needs analysis at SMP Negeri 2 Lambu through classroom observation, interviews with informatics teachers, and curriculum studies (Nabilah et al., 2022). Observations show that students have difficulty understanding the basic syntax of programming and the lack of interactive learning media. In the second stage, the development of an AI-based chatbot was carried out using an NLP-based conversation platform (such as Dialogflow or BotStar), which was adapted to the Informatics curriculum for grade VIII. The chatbot's content includes basic concepts of algorithms, logical structures, basic syntax recognition, and interactive exercises that are adaptive. Content validation is carried out by three experts: material experts, media experts, and pedagogues, by the content validity procedure as stated by Gregory (Setyowati et al., 2023).

After the chatbot is ready to be used, it is followed by the implementation stage in the field,

which is a limited experiment for four weeks in two classes at SMP Negeri 2 Lambu: one class as an experimental group, one class as a control. The instruments used include: (1) tests of understanding programming concepts (pretest and posttest), (2) student engagement observation sheets, and (3) perception questionnaires on the use of chatbots. The tests used have been tested for validity and reliability using Item Response Theory (IRT) analysis and internal consistency test (Cronbach's Alpha > 0.7). Pretest and posttest data were analyzed using an independent t-test and gain score analysis, while perception data were analyzed descriptively and quantitatively. During the implementation, chatbot interaction logs were also recorded to evaluate the types of questions that students most often asked, as complementary qualitative data.

The final stage is the analysis of results and reflection, which is carried out to determine the influence of chatbots on programming learning outcomes and student involvement during the learning process. The results of the study were interpreted based on effectiveness indicators, which included: increased concept comprehension scores, student active involvement levels, and feedback from teachers and students on the usefulness of chatbots. These findings are then juxtaposed with the results of previous research to strengthen the scientific position and expand the relevance of the findings in the context of junior secondary education. Methodologically, the entire research procedure refers to the principle of educational design research, which is oriented towards the development of contextual solutions based on real problems in the field (Parwati, 2015). Thus, this study not only provides empirical evidence regarding the effectiveness of chatbots in programming learning but also provides an implementation model that can be replicated in other schools that have similar characteristics.

FINDINGS AND DISCUSSION

Findings

This research produced an AI-based chatbot specifically designed as a virtual assistant in learning programming at SMP Negeri 2 Lambu. The following Figure 1 shows the developed chatbot interface, which allows students to interact directly to understand basic programming material.



Figure 1. AI-Based Chatbot Interface in Programming Learning

Figure 1 shows the main features of the chatbot, consisting of interactive menus, adaptive questions, and instant feedback designed to help students understand basic programming logic and syntax. Chatbots also allow students to practice questions independently with an automated evaluation system. To measure the effectiveness of using chatbots, here are the pretest and posttest results of the experimental group and the control group.

Table 1. Comparison of Pretest and Posttest Scores of Students

Group	Pretest (Average)	Posttest (Average)	Gain Score
Experiment (Chatbot)	52,40	82,60	0,63
Control (Conventional)	53,20	70,40	0,34

Table 1 shows that there was a significant increase in scores in the experimental group compared to the control group. The gain score in the experimental group reached 0.63, while in the control group it was only 0.34, which indicates that the use of AI-based chatbots has a positive impact on improving student learning outcomes. In addition to test results, students' perceptions of the use of chatbots were also collected through questionnaires. This perception data is summarized in Table 2 below.

Table 2. Recapitulation of Students' Perceptions of the Use of Chatbots

Statement	Percentage of Responses Agree (%)
Chatbot helps understand the material	88%
Chatbot is attractive and easy to use	92%

Statement	Percentage of Responses Agree (%)
Chatbots increase learning motivation	85%
Chatbots can be used independently	90%
Chatbot provides clear feedback	87%

Table 2 shows that the majority of students responded positively to the use of chatbots in learning. Students find it helpful in understanding the material and assessing chatbots as an interesting medium, and motivating them to learn more actively.

Discussion

The use of AI-based chatbots in learning programming has proven to be effective in improving the understanding of basic programming concepts for junior high school students. The results showed a significant increase in scores in the experimental group using chatbots compared to the control group using conventional methods. This is in line with the research of Wang et al., which states that chatbots can improve student engagement and performance in basic programming learning (Lee & Chen, 2025). Chatbots provide adaptive interaction and instant feedback that helps students correct mistakes quickly, as also described (Pérez et al., 2020).

In addition, the chatbot developed has been proven to be able to answer the needs of digital native students who want an interactive and flexible learning experience. Research by Lin et al. revealed that chatbots can increase students' motivation and courage in completing programming exercises (Huang et al., 2025). The features of chatbots tailored to the needs of junior high school students make it easier for them to access information independently, as also outlined in Okonkwo & Ade-Ibijola's study on chatbots as adaptive learning agents (Okonkwo & Ade-Ibijola, 2021). These findings show that chatbots are effective as learning companions that can bridge teachers' limitations in individual guidance.

The use of chatbots also has a positive impact on student perception. Most of the students in this study felt helped in understanding the material and were motivated to study more actively. These findings are in line with the results of a study by Smutny & Schreiberova, which showed that chatbots can increase student

satisfaction and motivation in a digital-based learning environment (Smutny & Schreiberova, 2020). Thus, chatbots not only function as material aids, but also as a medium that can improve the quality of interaction in learning. Positive perceptions of students strengthen the potential of chatbots as effective technology-based learning solutions at the junior high school level.

From a technical perspective, the AI-based chatbot developed in this study utilizes an NLP-based conversational platform that allows chatbots to provide natural and contextual responses. This is important to create a comfortable and non-intimidating learning atmosphere, as stated by Putri & Fitriyani in their study of chatbots that can reduce coding learning anxiety in students (Rachman et al., 2025). With humanistic and flexible responses, students are more encouraged to explore and ask questions without fear, which is an important characteristic in creating a supportive learning environment.

The results of the observation also showed that the involvement of students in the experimental group class was higher than that of the control group. Chatbots facilitate a more active learning process by providing challenging questions and materials that can be accessed at any time. This supports the findings of Tegos et al., which affirm the role of chatbots in enhancing productive discussion and collaboration in learning (Tegos et al., 2020). Intense interaction between students and chatbots provides a more dynamic and enjoyable learning experience, which is in line with 21st-century learning approaches.

Chatbots also allow for learning personalization that is rare in conventional methods. Through the interaction logs, it can be seen that students ask diverse questions according to their needs. This is in line with the research of Rodríguez et al., which emphasizes the importance of using chatbots to support adaptive individualized learning (Khosrawi-Rad et al., 2022). With this personalization, students can learn according to their own pace and learning style, which is one of the principles of Freedom of Learning.

The use of chatbots provides an advantage in strengthening students' digital literacy, as they are used to interacting with AI-based technology. Research by Zawacki-Richter et al. shows that the integration of AI in education is able to improve digital literacy and problem-solving

(Zawacki-Richter et al., 2019). Through the use of chatbots, students not only learn programming materials but also build digital competencies that are essential to face future challenges. Chatbots are an effective medium that encourages students to be active in a productive digital environment.

From the results of the chatbot log analysis, it can be seen that students ask the most questions related to basic logic and syntactic errors. This shows that chatbots are an effective medium to provide scaffolding according to the proximal zone of student development, as explained by Vygotsky's theory. Research confirms that chatbots are effective in providing direct support at points of learning difficulties (Fadhil & Gabrielli, 2017). Thus, chatbots not only serve as material presenters but also as companions who understand the specific learning needs of each student.

Overall, the study provides strong evidence that AI-based chatbots are effective in improving learning outcomes, student engagement, and motivation in programming learning. These findings expand on the results of previous studies and make a practical contribution to the development of contextual digital learning media. Chatbots are not only useful in urban schools, but also have the potential to be applied in suburban schools such as SMP Negeri 2 Lambu that face limited resources. The integration of chatbots into learning is a strategic step in adopting learning that is relevant to the digital era.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the use of AI-based chatbots as virtual assistants in programming learning at SMP Negeri 2 Lambu has proven to be effective in improving student learning outcomes. A significant increase in posttest scores and gain scores in the experimental group showed that chatbots were able to help students understand programming materials better than conventional learning methods. In addition, chatbots provide an interactive and flexible learning experience that matches the characteristics of digital native generation students. Students' positive perceptions of the use of chatbots, both in terms of ease of use, increased motivation, and clarity of feedback, further strengthen the effectiveness of this media in supporting programming

learning. Chatbots also contribute to increasing student engagement during the learning process, enabling material personalization, as well as facilitating adaptive self-paced learning. Thus, chatbots not only function as a learning aid but also as a responsive and communicative learning companion. This study provides empirical evidence that the integration of chatbots in programming learning at the junior high school level, especially in schools with limited access, such as SMP Negeri 2 Lambu, is a strategic solution that can address learning challenges in the digital era. Further development prospects of this research are to expand the application of AI-based chatbots to other subjects, as well as to integrate multimedia features to enrich students' learning experiences. In addition, the application of chatbots can be developed on a wider scale in various educational units, both in urban and rural areas, as part of an inclusive education digital transformation. Further research can also be directed to examine the long-term impact of chatbot use on the improvement of students' computational thinking skills and 21st-century skills.

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