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The Role of AI-Based Chatbots in Supporting Biology Education Students' Learning

Ayu Wahyuni [1*], Agus Junaidi[2], Mansur[2], Sriadhi[2], Futria Halimatun[1]
[1]Samudra University, Aceh, Indonesia
[2]Medan State University, North Sumatera, Indonesia

**Email: ayuwahyuni@unsam.ac.id*

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Abstract

The development of Artificial Intelligence (AI) technology continues to make a significant contribution to the field of education, particularly through the use of chatbots as virtual learning assistants. AI-based chatbots can help students overcome learning difficulties, whether in understanding material, increasing motivation, or providing guidance tailored to individual needs. This study aims to analyze the effectiveness of AI-based chatbots in enhancing Biology Education students' understanding and ability to overcome learning difficulties in the digital learning environment. This study uses a quantitative survey method, involving 60 respondents from the Biology Education Study Program at a state university in Indonesia. The population in this study consists of all students in the Biology Education Study Program who have used AI chatbots as learning tools. The sampling technique used is purposive sampling, with the criteria being students who have used AI chatbots for at least one semester in their learning activities. Data were collected using a structured questionnaire based on five indicators: ease of access, clarity of material explanation, learning motivation, effectiveness of feedback, and contribution to conceptual understanding. The results of the study show that students consider AI chatbots to be effective learning tools, especially in providing instant feedback, clear explanations, and improving their understanding of basic and complex biological concepts. Most students showed a high level of acceptance of chatbots. The students appreciated its accessibility, clarity, and relevance of responses. The analysis also shows that chatbots serve as facilitators of independent learning, which strengthens motivation, increases confidence, and deepens conceptual understanding. However, this study also found that the effectiveness of chatbots still needs improvement, especially in providing more contextual explanations and supporting higher-order cognitive skills such as analysis and synthesis. In conclusion, students rated the AI chatbot as an effective learning tool because it provides instant feedback, clear explanations, and improves their understanding of biological concepts. The chatbot also supports independent learning, motivation, and confidence. However, its effectiveness still needs to be improved, especially in providing contextual explanations and supporting higher-order cognitive skills.

Keywords: analysis; artificial intelligence (AI); biology education; chatbot; learning difficulties

INTRODUCTION

Higher education faces various learning challenges, including students' diverse backgrounds and abilities, varying levels of motivation, difficulties in understanding complex material, and the growing need for more personalized learning. On the other hand, the development of artificial intelligence (including adaptive learning systems, intelligent tutoring systems, early detection systems, and large language models) offers the potential to reduce this learning gap and provides students with wider access to various learning resources and technologies that facilitate the learning process (Putri, 2023; Laili *et al*., 2025). The development of digital technology has changed various aspects of life, including in education. The development of Artificial Intelligence (AI) technology is increasingly making a significant

contribution to the world of education, especially through the utilization of chatbots as virtual learning assistants. A chatbot is a computer program that can interact with users automatically and responsively, so that it can help students in overcoming learning difficulties anytime and anywhere (Rahmah & Zahra, 2025). In education, AI-based chatbots act as virtual assistants that support students in overcoming learning difficulties by providing real-time feedback, enhancing understanding, boosting motivation, and offering personalized guidance (Chua & Annamalai, 2025; Febrianti *et al*., 2025).

Learning difficulties continue to be a significant problem among students, influenced by internal factors such as lack of motivation and inadequate study skills, as well as external factors including material complexity, limited learning strategies, and insufficient access to learning guidance (Mugnianingsih *et al.*, 2022; Zendrato *et al*., 2024). With the presence of AI technology, chatbots can function as interactive learning assistants that help students understand lecture material by providing instant answers, personalized feedback, and consistent study reminders, thereby addressing common learning challenges such as limited access to lecturers or tutors and difficulties in understanding material independently (Agustini, 2023; Moons, 2025). Students often experience obstacles in understanding abstract concepts, managing study time, and limited access to guidance from lecturers. Chatbots powered by AI technology can serve as innovative virtual tutors that help bridge lecturers' limited time and resources with students' diverse needs by providing real time answers, personalized guidance, discussion facilitation, and twenty four hour access to academic support (Muliyono & Sumijan, 2021; Suryanto *et al*., 2024; Basri & Ernawati, 2025).

The rapid development of biology at the university level requires students to master complex concepts as well as critical thinking and problem solving skills. Biology courses often contain abstract and conceptual material such as genetics, physiology, and ecology so that many students experience learning difficulties which result in gaps in conceptual understanding and low motivation to learn (Utami *et al*., 2021; Yonanda *et al*., 2023; Sura *et al*., 2024). In addition, limited face to face time and variations in pre knowledge abilities among students reinforce the need for learning aids that can provide immediate feedback and personalize learning. The technology of AI-based chatbots offer the potential to meet students' learning needs by providing on demand assistance, answering questions, delivering clear explanations, and supporting tasks such as practice, concept clarification, and personalized learning paths, thereby enhancing accessibility, motivation, and continuity of learning outside lecture hours, although their implementation varies across disciplines (Navisa *et al*., 2025; Riyadi & Budiyanto, 2025).

Technology of AI chatbot such as ChatGPT is very effective in learning because it provides personalized learning experience, instant feedback, and flexible learning accessibility every time we need to use it. Chatbots help students overcome learning challenges, increase motivation, and deepen understanding of complex concepts through engaging and clear natural language interactions. In addition, chatbots function as self learning facilitators that not only enhance students' confidence and foster their acceptance of technology in educational contexts, but also provide timely feedback and contextually relevant explanations that promote autonomous learning and material personalization; furthermore, AI chatbots simplify the learning process, enhance engagement, and cultivate students' capacity for independent learning (Al Husaeni *et al*., 2024; Suryanto *et al.*, 2024). On the other hand, the literature also highlights important limitations such as response accuracy, the risk of misinformation dissemination, and ethical or dependency issues that need attention when integrating AI chatbots into the learning process (Wahyuningsih *et al*., 2025). Moreover, most empirical studies on the perception and use of chatbots in education concentrate on general STEM fields or languages, while research focusing on biology education students, specifically regarding their understanding of using chatbots as a strategy to overcome learning difficulties is relatively limited. This research void makes it difficult for universities to design effective and contextually appropriate chatbot based interventions for biology (Lin & Ye, 2023; Sariyati, 2025).

With a chatbot, students can get help quickly and effectively without having to rely on face to face interactions (Modiba & Mahlatse, 2024; Julianto *et al*., 2025). Chatbots can also improve the accessibility of educational services and provide quick solutions to the difficulties faced by students. This helps students learn independently and focus more on material they have not yet mastered. It was found that the use of chatbots can increase students' learning motivation because chatbot interactions make the learning

process more interesting and interactive (Labadze *et al*., 2024; Fadhilah & Nuriza, 2025). Therefore, based on this background, this study aims to analyze the effectiveness of AI-based chatbots in enhancing Biology Education students' understanding and ability to overcome learning difficulties in the digital learning environment.

METHOD

This study employed a descriptive quantitative method with a survey approach, chosen to systematically describe the level of understanding of Biology Education students in utilizing AI-based chatbots to overcome learning difficulties, as descriptive quantitative research aims to present phenomena factually and based on numerical data obtained through standardized instruments (Karimuddin *et al*., 2022; Putri *et al*., 2023). The population in this study were all students of the Biology Education Study Program at one of the state universities in Indonesia who had used an AI chatbot as a learning aid. The sampling technique used was purposive sampling, with the criteria of students who have used AI chatbots for at least one semester in learning activities. The number of samples taken was 60 respondents. The instrument used was a closed questionnaire with a 5 point Likert scale (strongly disagree, 4 = strongly agree). The questionnaire was designed with 25 items, developed based on five indicators of student understanding in the use of AI chatbots, which include ease of access, clarity of explanation, motivation to learn, effectiveness of feedback, and improvement in understanding the material. Each indicator was assessed through five items, resulting in a total of 25 questions. The questionnaire was developed based on the study of learning comprehension and previous research on chatbots in learning.

Before use, the questionnaire was validated through content validity by three experts, namely lecturers in Biology Education, learning technology experts, and educational measurement experts. The instrument's validity was evaluated using the Content Validity Index (CVI) with a threshold of ≥ 0.78, and its reliability was assessed with Cronbach's Alpha, considered acceptable at $\alpha \geq 0.70$ (Jurwita *et al*., 2024; Wibowo *et al*., 2025). This process ensured that the questionnaire items were relevant, clear, and capable of accurately measuring students' understanding. Any suggestions or corrections provided by the experts were carefully considered and incorporated into the final version of the instrument. The items were then organized logically to facilitate smooth completion by the respondents. Efforts were also made to ensure that the language used was simple, precise, and easily understandable. A pilot test was conducted with a small group of students to further check clarity and comprehension. Feedback from the pilot test was used to make minor revisions to the questionnaire. Finally, the instrument was prepared for full-scale distribution to the target respondents.

Data were collected by distributing questionnaires through the google form online platform. Each respondent was asked to fill in basic identity (anonymous) and answer all questions according to personal experience in using AI chatbot for biology learning. To ensure a high response rate, reminders were sent to participants, and clear instructions were provided for completing the questionnaire. Data were analyzed using descriptive statistics including average scores, percentages, and categories of student understanding levels on each indicator. The category is determined by the score interval formula and can be seen in Table 1 (Al-Abdullatif, 2023). Prior to analysis, all collected responses were carefully reviewed to ensure completeness and consistency of the data. Any incomplete or inconsistent responses were excluded from the final dataset to maintain data quality. The final dataset was then organized systematically to facilitate accurate interpretation of results.

Table 1. The criteria for interpreting the results are as follows

Mean Value Range	Criteria	General Interpretation
1.00 – 1.75	Very Low	Chatbot does not help at all / very ineffective
1.76 – 2.50	Low	Less effective, students still have difficulties Chatbot moderately helps the learning process
2.51 – 3.25	High (Fairly Good)	Chatbot is very helpful and effective
3.26 – 4.00	Very High (Good)	

RESULT AND DISCUSSION

The effectiveness of chatbots in educational settings relies on their ability to provide timely, relevant, and user-friendly interactions that meet students' academic and personal needs. When students feel that the chatbot is intuitive and easy to navigate, they are more likely to integrate it into their daily learning routines. Furthermore, chatbots can reduce the workload of educators by handling repetitive inquiries, allowing teachers to focus on more complex pedagogical tasks. The conversational nature of chatbots also promotes a more personalized learning experience, helping students receive instant feedback and continuous academic support. However, despite their potential, the acceptance of chatbot technology is still influenced by several factors such as technical reliability, accessibility, and students' digital literacy levels. Challenges such as system errors, slow responses, or limited comprehension of complex queries can negatively impact user satisfaction and trust. Therefore, successful implementation requires not only robust technical design but also continuous evaluation of user experience and learning outcomes to ensure that the chatbot effectively supports educational objectives and fosters a positive digital learning environment.

Based on the data, the majority of respondents agreed (63-70% on average) that the AI chatbot was easy to access and use, with a large proportion strongly agreeing (around 20-33%). This shows that from a technical perspective, the chatbot has fulfilled the accessibility aspect. However, there are still around 13-33% of respondents who disagree on items such as ease of login and technical constraints (items 3 and 5). This finding found that the factors of ease of access and ease of use are the main determinants of the acceptance of AI-based learning technology by students (Rahim *et al*., 2022; Goli *et al.*, 2023). In addition, through the Technology Acceptance Model (TAM) explains that perceived ease of use significantly influences user intention in adopting new technology (Davis, 1989; Venkatesh & Bala, 2008; Udiyana & Yasa, 2025). A chatbot designed with a simple interface and fast response time will increase students' acceptance of digital learning technology.

Most respondents (65-73% on average) agreed that the AI chatbot provided clear and relevant explanations, with around 10-20% strongly agreeing. This shows that the chatbot has functioned quite well in delivering learning materials with easy-to-understand language. However, there were still around 13-25% respondents who rated the ambiguity or lack of clarity of information (item 10).This finding is consistent with research which shows that the quality of information and clarity of chatbot answers have a significant effect on students' concept understanding (Fu *et al.*, 2025; Qiu *et al*., 2025). A chatbot with good Natural Language Processing (NLP) skills can explain difficult concepts with contextual examples, increasing the effectiveness of self-learning. Improving the quality of language and context adjustment in chatbots can strengthen the clarity of the material and reduce the ambiguity of answers.

Most students (around 70-78%) agreed that AI chatbots increase learning motivation, confidence, and independence (items 11-15). Nevertheless, there are still around 20-30% of respondents who show doubts in the aspect of learning consistency. This result supports previous research showing that AI-based educational chatbots can enhance students' intrinsic motivation by providing quick, non-judgmental feedback, consistent with self determination theory which states that autonomy and competence supportive interactions foster long term motivation (Deci & Ryan, 2017; Uroj *et al.*, 2025). Students reported that interacting with the chatbot made it easier to explore learning materials at their own pace, revisit explanations without pressure, and reduce anxiety commonly felt in traditional classroom settings. Beyond theoretical learning, the chatbot also proved helpful in laboratory activities, guiding students through data analysis such as evaluating spinach growth under different fertilizer treatments, examining the effects of snail mucus on collagen production, and understanding phylogenetic relationships among snail species (Husniyyah *et al*., 2025; Pertiwi, *et al*., 2025; Pertiwi, *et al.,* 2025). By providing immediate support in interpreting experimental results and clarifying procedures, the chatbot made complex lab tasks more approachable and encouraged independent, confident engagement with both practical and conceptual aspects of Biology Education.

Building on these findings, it is important to note that the effectiveness of a chatbot is not solely determined by how clearly it delivers information or how much it boosts motivation, but also by its ability to adapt to diverse learning needs. In the context of Biology Education which requires both conceptual understanding and practical skills, an effective chatbot should ideally provide dynamic explanations that match the user's level of competence. This includes adjusting the depth of content, ranging from beginner friendly summaries to more advanced, detail rich explanations, ensuring that each student experiences learning that feels personal and relevant. In addition, the chatbot should be equipped with more reflective types of responses, such as asking follow up questions or offering metacognitive prompts that encourage students to evaluate their own understanding. These features can help strengthen students' self regulation abilities, which are critical indicators of successful independent learning. With more adaptive and responsive interaction design, the chatbot can function not merely as an informational tool but as a genuine learning partner, capable of creating deeper, more meaningful, and more sustainable learning experiences for all users.

This indicator showed the highest score of all aspects, more than 80% of respondents agreed or strongly agreed that the AI chatbot provided quick, relevant feedback and helped correct learning errors (items 16-20). Research shows that one of the main strengths of AI in education is its ability to provide real time formative feedback that accelerates learning cycles and supports student self reflection, aligning with findings that adaptive chatbot feedback can strengthen critical thinking and problem solving skills and thereby make chatbots effective tools for reflective and high skill based learning (Kukulska-Hulme, 2020; Zawacki-Richter, 2019). Students also reported that the immediacy of the chatbot's responses made them more confident in identifying and correcting mistakes before they became persistent misconceptions. Moreover, the presence of instant feedback encouraged learners to engage in repeated practice without feeling discouraged by delays or uncertainty. This consistent interaction appears to cultivate a more proactive approach to learning, where students feel motivated to revisit material until they fully understand it. Additionally, the clarity and structure of the feedback provided by the chatbot were perceived as helpful in guiding students through complex tasks that usually require instructor assistance. Overall, the feedback mechanism offered by the AI chatbot seems to play a crucial role in strengthening learning autonomy and facilitating deeper, more continuous engagement with study materials.

Most respondents (around 70-80%) stated that the use of AI chatbots helped them understand concepts and answer difficult tasks (items 21-25). This indicates that the chatbot is not only a technical aid, but also a means of cognitive reinforcement. Technology of AI-based chatbots can serve as "learning partners" that improve students' metacognitive abilities and conceptual understanding through dialog based interactions (Yin *et al.*, 2023; Yin *et al*., 2024). In the context of constructivist learning theory, this interaction allows students to construct new knowledge through reflection and active conversation. The use of AI chatbots supports active and constructivistic learning, where students act as knowledge builders, not passive recipients. Furthermore, receiving immediate feedback from the chatbot encourages students to evaluate their understanding continuously and make adjustments during the learning process.

The Table 2 shows the results of percentage analysis data from five indicators that measure Biology Education students' understanding of using AI chatbots to overcome learning difficulties. Analysis of Table 2 shows that the majority of Biology Education students have a very positive perception of using AI chatbots to overcome learning difficulties. For example, the "Ease of access" indicator had approximately 85% of respondents selecting "Agree" or "Strongly agree" (63.3% + 22.34%), indicating that most students find the chatbot easy to access. The "Effectiveness of feedback" indicator was also very high, with ~91.66% of respondents agreeing (78.66% + 13%), demonstrating that timely and relevant feedback from the chatbot is highly appreciated. Research shows that while chatbots providing metacognitive feedback can enhance knowledge retention and conceptual understanding, their overall effectiveness may vary depending on design and context, with some aspects such as motivation and critical thinking showing only moderate effects (Deng & Yu, 2023; Yin *et al*., 2024). Interestingly, the "Motivation to learn" indicator had ~82.68% agreement ("Agree" + "Strongly agree"), yet about 19% of

respondents chose “Less agree,” suggesting that while most students feel their motivation is supported, a portion still experiences uncertainty or limited benefits. This implies that although technical aspects like accessibility and feedback are strong, factors such as system adaptation, user training, or quality of interaction may still present challenges. Overall, the data indicate that AI chatbots are highly promising in supporting Biology learning and are well-received by students, but careful attention to implementation and context is required to fully maximize their cognitive and affective benefits.

Table 2. Results of data analysis of biology education students' understanding of using AI chatbot to overcome learning difficulties

Indicator	Percentage (%)			
	Disagree	Less agree	Agree	Strongly agree
Ease of access	1.34	13.32	63.3	22.34
Clarity of material explanation	0.34	16.34	64	15
Motivation to learn	1.02	19	73	9.68
Effectiveness of feedback	0.34	9.68	78.66	13
Increased understanding of material	0	13.66	74.7	63.3

In summary, the findings from this study indicate that AI chatbots offer substantial benefits for learning in Biology Education, combining accessibility, timely feedback, and cognitive support to enhance student understanding. The positive responses across multiple indicators suggest that students are not only able to access the technology easily but also engage more actively with complex material and correct errors in real time. Chatbots appear to foster a more autonomous learning environment, encouraging learners to take responsibility for their own progress and build confidence through repeated practice. Additionally, the dialog based interaction provided by the chatbot supports reflective thinking, allowing students to consolidate knowledge while developing problem solving skills. Motivation is also positively influenced, as students are more willing to explore challenging tasks knowing they have immediate support. Despite some variation in responses, particularly regarding motivation and adaptation, the overall pattern demonstrates that chatbots can complement traditional teaching methods, bridging gaps where direct instructor interaction is limited. The consistent use of AI tools may also contribute to long term learning habits, creating an environment where students can review, reflect, and engage with material at their own pace. Overall, the integration of AI chatbots represents a meaningful step forward in educational technology, providing both practical and cognitive advantages that enhance the learning experience. Future research should focus on improving chatbot design to better support analytical and synthesis skills, as well as integrating more contextual and inquiry-based explanations to enhance higher-order thinking in biology learning.

CONCLUSION

Based on the findings, AI-based chatbots are effective in enhancing biology education students’ understanding and ability to overcome learning difficulties in digital learning environments. The majority of students demonstrated high acceptance of chatbot use, particularly in terms of accessibility, clarity of explanations, and the speed and relevance of feedback. Chatbots function as facilitators of independent learning that foster motivation, confidence, and comprehension of complex biological concepts. However, their effectiveness remains limited in providing deeper contextual explanations and supporting higher order thinking skills, indicating the need for further refinement. At a broader level, the integration of AI-based chatbots in biology education has the potential to support national efforts in improving the quality of science education, strengthening STEM literacy, and accelerating the digital transformation of learning to prepare students for the demands of science and technology development in Indonesia.

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