EDUTECH

Jurnal Teknologi Pendidikan

Journal homepage https://ejournal.upi.edu/index.php/edutech

ChatGPT Assistance on Biochemistry Learning Outcomes of Pre-Service Teachers

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ABSTRACT

This research investigates the effect of ChatGPT on the learning outcomes of pre-service biology teachers. Sampling was done by purposive sampling in class A (treated with ChatGPT) and class B (Control) of pre-service biology teachers. There were 3 meetings in each class, with a system of material presentation, review, and test at each meeting. Sampling was done using the Quizizz platform, and it was found that the speed of answering class A (ChatGPT) was faster than class B (Control), but the accuracy of the answers was not significantly different. This could be because ChatGPT presents the material in an easy-to-understand version, but uses the same source of reference material as other conventional search engines. ChatGPT has also been shown to be effective and very easy to use by pre-service biology teachers and can increase their motivation to learn. Challenges such as technical and network disruptions and concerns about ChatGPT dependency, also need to be addressed by policy makers and educators. This study proves that ChatGPT is a valuable learning tool for students, but its presence cannot replace the role of teachers or other conventional sources of information. Through this research, it is hoped that it can provide insight to policymakers and educators, to be able to maximize the potential of ChatGPT, to increase the efficiency and ease of learning for students.

ARTICLE INFO

Article History:
Submitted/Received 12 Dec 2024
First Revised 15 Jan 2025
Accepted 07 Feb 2025
First Available online 01 Jun 2025
Publication Date 01 Jun 2025

Keyword:
ChatGPT, Education, Pre-service biology teachers, Perception, Learning

1. INTRODUCTION

Artificial intelligence (AI) is a field of computer science that focuses on creating systems capable of performing tasks that would normally require human intelligence. This intelligence is not produced by living beings such as humans or animals, but rather intelligence that is generated by a machine (Saleh, 2019). The concept of AI was first introduced by John McCarthy in 1956 at the Dartmouth conference. Since then, AI has grown rapidly and made a significant impact in areas such as healthcare, finance, transportation, and manufacturing (McCarthy et al., 2006).

AI can be divided into several types based on its level of intelligence (Saghiri, 2020); Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), and Artificial Superintelligence (ASI). ANI, also known as Narrow AI or Weak AI, is a type of artificial intelligence designed to perform certain tasks very well. Examples include facial recognition, product recommendations, and virtual assistants like Siri or Alexa. ANI is only capable of handling the tasks that it has been programmed for and cannot perform tasks beyond that. AGI, or General AI, is a type of artificial intelligence that can understand, learn, and apply knowledge in general, like human cognitive abilities. AGI can perform a wide range of intellectual tasks with great flexibility, allowing the machine to learn and adapt to new situations without requiring specialized programming for each task. ASI refers to artificial intelligence that surpasses human intelligence in all aspects, including creativity, problem-solving, and decision-making. ASI has the potential to do work that humans cannot, in terms of speed, accuracy, and scale. ASI is still theoretical and has not yet materialized in practice.

In education, AI has made many contributions to both students and teachers. In a time where young people tend to spend their time with smartphones or gadgets, it gives them the opportunity to use AI applications as learning tools. As a teacher or lecturer, AI can help teachers to understand the mood or learning process of students during learning, through gesture analyzer technology. AI can also help teachers speed up the grading process of student assignments (Holmes et al., 2019), and address gaps in learning. In personalized learning, AI algorithms can adapt to the individual needs of students, which in turn can improve learning effectiveness (Kengam, 2020). In addition, AI also helps learners to gain essential skills needed in the 21st century (Luckin et al., 2016).

Biochemistry is an important course for students, especially medical, biology, and chemistry students. pre-service teachers of biology also need to understand and master biochemistry to pass on their understanding to their students. However, most university students still find this course very difficult. (Elhousni et al., 2023). Past research has shown that AI can significantly improve efficiency and accuracy in various biochemical applications. A study, revealed that the use of deep learning algorithms such as AlphaFold has successfully predicted protein structures with accuracy close to laboratory experiments (Jumper et al., 2021). The research shows that AI can reduce the cost and time required for protein structure research. Since we believe that teachers play a critical role in facilitating the achievement of educational reforms (Smith & Desimone, 2003 ;

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

Spillane & Callahan, 2000), it is essential to understand how AI can give impact on learning outcome of pre-service biology teachers. This gives us hope that in the classroom, AI can help pre-service biology teachers understand important concepts from biochemistry courses.

ChatGPT is a highly intelligent chatbot created by OpenAI's GPT technology. ChatGPT has a very wide range of capabilities in solving or answering text questions, from simple questions to very demanding tasks. (Lund, 2022). ChatGPT has also been shown to improve the search and discovery of references or sources of information, related to research. (Lund & Wang, 2023). ChatGPT was developed as a conversational agent capable of interacting with users, which is supported by several social experiments that show ChatGPT tends to give responses like human answers. ChatGPT can also sometimes correct its own mistakes, although it often shows overconfidence in giving incorrect responses. ChatGPT also sometimes requires additional information to provide the right answer. Another limitation is that small changes to a question can cause ChatGPT to produce conflicting responses (Azaria, 2022). However, the most perceived benefit, especially for students, is the ease of information provided by ChatGPT. ChatGPT is different from Google, where Google provides responses that refer to certain specific websites, while ChatGPT provides direct responses, like chatting with a mentor (Chinonso et al., 2023). ChatGPT has the potential to replace the role of conventional search engines that provide billions of results. Scanning through conventional search engines, it requires a very long time to find relevant and trustworthy information. ChatGPT offers an alternative to provide simple results that can be generated as many times as desired by the user(Alafnan et al., 2023). ChatGPT also helps students develop the confidence and skills necessary to succeed in academic life (Diantama, 2023). Even at the higher education level, AI-based technologies such as ChatGPT are proven to provide many benefits including increased effectiveness of student services, admissions, retention, and significantly improved teaching and research activities (Dempere et al., 2023). ChatGPT can also help instructors integrate technology in the classroom and provide students with discussion and evaluation examples from the workshop section(Alafnan et al., 2023). Not only that, but ChatGPT also has a good sympathy ability in helping to support the mental health of the responder. Humans have a limited ability to listen, whereas ChatGPT will not get bored and can continue to be available to listen and reply sympathetically to visitors' questions. (Nazir & Wang, 2023). This can also be utilized in supporting mental health in schools.

Although there has been a lot of research related to the influence of AI, especially ChatGPT in the world of education, there is still no specific research on the effect of ChatGPT on the learning outcomes of pre-service biology teacher students, in the Biochemistry course in higher education. This study aims to determine how ChatGPT affects the learning outcomes and response speed of pre-service biology teacher students in biochemistry courses in higher education. Not only that, this study also aims to understand the perceptions of biology pre-service teachers towards ChatGPT in learning. Through this study, it is expected to be a reference for policymakers and educational

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

institutions, to be able to maximize the potential of AI, especially in this context, ChatGPT, as a student learning tool for more effective learning.

2. METHODS

To understand how ChatGPT affects the speed and accuracy of answering biology pre-service teachers, we chose to use a quantitative research design. Whenever this article mentions ChatGPT, it refers to ChatGPT 3.5, which is widely accessible. The respondents in this research are 2 classes of biology pre-service teachers, the entry year 2022, who are taking biochemistry courses in November 2023. The two classes were given different treatments, Class A with 34 respondents, was given access to ChatGPT (Research class). Class B with 35 respondents, was not allowed to open access to any AI, especially ChatGPT (Control Class).

The mechanism given is, that one group of pre-service biology teachers presented the material, while other pre-service biology teachers listened to the material exposure given by the presenting group. There is a difference in access for pre-service biology teachers from class A and class B. In this case, class A pre-service biology teachers were directed to ChatGPT for answers to questions they may have during the presentation. Meanwhile, class B was instructed to use ordinary internet platforms, such as Google, YouTube, journals, or certain websites (not any of the AI-related websites). Following the presentation of the material, students were given time to study and review the material they had studied that day. Class A was instructed to review material from ChatGPT, while Class B was instructed to review material from other internet sources. After reviewing the material, Class A and Class B were given tests that were in accordance with the material that had been learned through the Quizizz platform. The material tested and the tests given between class A and class B were made the same, including explanations and directions from the supervisor. In addition, Quizizz was used to determine the speed and accuracy of students' answers, which can then be used for further analysis. This study was conducted for 3 meetings in each class, with the first meeting discussing carbohydrate metabolism, the second meeting discussing protein and fat metabolism, and the last meeting discussing diseases surrounding metabolism.

All processing, visualization, and statistical tests will be performed using a Python programming language with Pandas, Matplotlib, and SciPy library, based on the data obtained from the 3 meetings of each class. To test whether the data were normal in the time analysis, the non-parametric Shapiro-Wilk's W test was performed first (Liang et al., 2009). Shapiro-Wilk's W was used because its sensitivity and consistency as a normality shift detection test exceeds that of Kolmogorov-Smirnov, Lilliefors, and Anderson-Darling tests especially on small to medium datasets (Pearson & Bowman, 1977). In the initial implementation, Shapiro provided a sample limit of less than 20 data which was then continued by Royston by approximating the normalization transformation to increase the effectiveness of implementation on computers and increase the sample capability to 2000

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

data (Royston, 1982). The results of Shapiro-Wilk's W show that the answering speed data is normally distributed so that the parametric t-test can be used (Kim, 2015). The parametric t-test has more performance with much fewer sample requirements than non-parametric tests such as the Mann-Whitney U test (Fagerland, 2012). The t-test is often used due to its efficiency and guaranteed performance (Kim, 2015). In addition, the t-test can also adapt to data that is not perfectly normally distributed (Zimmerman, 1998). For accuracy analysis, Shapiro-Wilk's W did not indicate that the data were normally distributed. Therefore, the non-parametric Mann-Whitney U test was used (McKnight & Najab, 2010). In non-normal distributions, it has been shown that the Mann-Whitney U test performs better than the t-test (Gibbons & Chakraborti, 1991).

Then we also analyzed the perception of classes using ChatGPT, using a structured questionnaire, consisting of quantitative and qualitative sections. The quantitative part used Likert scales to numerically measure respondents' perceptions, and the qualitative part used open-ended questions to gain deeper insights into respondents' thoughts and feelings (Johnson & Christensen, 2014). Likert scale is a measurement tool method used to assess individual opinions on certain specific issues (Alkharusi, 2022). The use of Likert Scales and Likert-type items has served the research community well over the years (Willits et al., 2016). The questionnaire contained 5-point Likert scale questions; strongly disagree, disagree, neutral, agree, and strongly agree. The questions asked through the questionnaire were "How effective is ChatGPT in helping you understand learning?", "How easy is it for you to use ChatGPT for learning purposes?", "How much impact does ChatGPT have on learning motivation?", and “How often do you experience technical difficulties when using ChatGPT?”. Then after analyzing the calculation, it will be matched with the interval interpretation table below (Alkharusi, 2022; Putri & Suryati, 2016).

Table 1. Linkert scale interpretation (Putri & Suryati, 2016)

Quantitative Score Percentage Range (%)	Interpretation
0 ≤ score < 20	Strongly disagree
20 ≤ score < 40	Disagree
40 ≤ score < 60	Neither agree nor disagree
60 ≤ score < 80	Agree
80 ≤ score ≤ 100	Strongly agree

As for the open-ended questions, we provided 3 questions, "How did you experience using ChatGPT?", "How do you compare your learning experience using ChatGPT with your experience using other learning resources (such as textbooks, learning videos, or

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

other online platforms)?", and finally "After using ChatGPT, do you find it easier to do assignments or understand the subject matter? Tell us about your experience". The research questions above were developed based on previous research that has analyzed students' perceptions of ChatGPT in education (Ngo, 2023), as well as its comparison with other conventional information search engines (Alafnan et al., 2023; Chinonso et al., 2023)

3. RESULTS AND DISCUSSION

Result

Based on the results of the two-sided T-test, it was conducted to test the hypothesis that the answering time of students in Class A is faster than that of Class B. The null hypothesis (H0) states that the average answer time of Class A is slower or equal to that of Class B (μA ≥ μB), while the alternative hypothesis (H1) states that the average answer time of Class A is faster than that of Class B (μA < μB). Statistical tests were conducted with a critical value of α = 0.05 using the `ttest_ind` function from the `SciPy` library in Python. The T-test result shows a p-value of 0,00002, which is smaller than 0.05. Therefore, the null hypothesis is rejected. This shows that there is a significant difference in the average answer time between Class A and Class B, where Class A has a faster answer time compared to Class B (Figure 1).

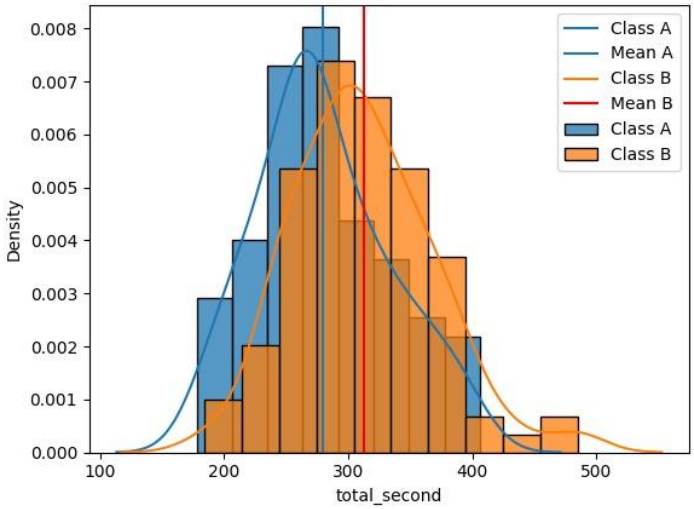

Figure 1. Speed of answering pre-service biology teachers for class A (ChatGPT) and class B (Control)

For the accuracy analysis, the non-parametric Mann-Whitney U test was employed. This test was used to determine if there was a significant difference in accuracy between Class A and Class B. The null hypothesis (H0) states that the average accuracy of Class A is the same as Class B (μA = μB), while the alternative hypothesis (H1) states that the average accuracy of Class A is different from Class B (μA ≠ μB). Statistical tests were performed with a critical value of α = 0.05 using the `mannwhitneyu` function from the `SciPy` library in Python. The Mann-Whitney U test results show a u-statistic value of 5296.5 and a p-value of 0.165, which is greater than 0.05. Therefore, the null hypothesis fails to be rejected. This indicates that although Class A had access to ChatGPT, their answer accuracy was not significantly different from Class B who used regular internet sources (Figure 2).

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

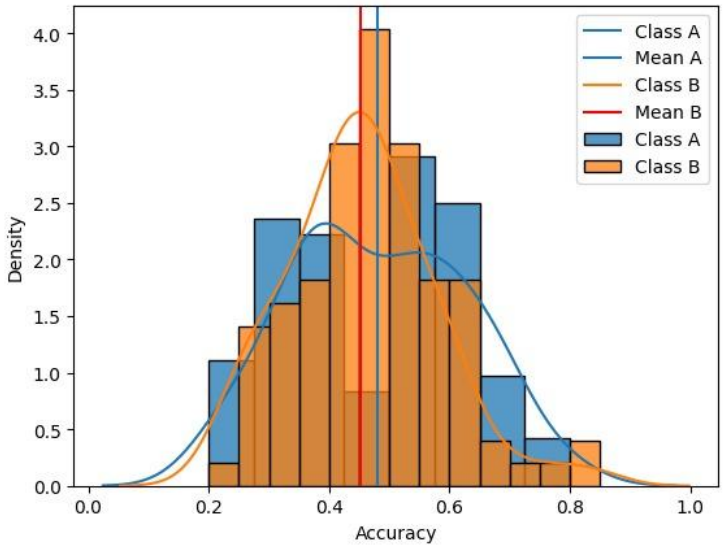

Figure 2. Accuracy of answering pre-service biology teachers for class A (ChatGPT) and class B (Control)

Furthermore, we also measured the perception of pre-service biology teachers towards the use of ChatGPT in learning. We used a Likert scale and analyzed the effectiveness of ChatGPT in assisting learning, how easy it is to use ChatGPT in learning, the impact of ChatGPT on learning motivation, and how often they experience difficulties when using ChatGPT. The results of the Likert scale analysis and its interpretation are summarized in Table 2.

Table 2. Biology Pre-service Teacher's Perception of ChatGPT

Statement	Index (%)	Interpretation
ChatGPT effectively helps understand lessons	79.42	Agree
ChatGPT is easy to use for learning purposes	87.43	Strongly agree
ChatGPT has a big impact on learning motivation	72.00	Agree
Frequently experience technical difficulties when using ChatGPT	63.43	Agree

The first open-ended questions were related to the experience of using ChatGPT, most pre-service biology teachers gave positive answers and were satisfied with the use of ChatGPT. They also mentioned that ChatGPT was very helpful and the language was easy to understand. The following are some examples of student's responses:

"Very helpful and the language is understandable"

"Quite helpful to understand the material, ChatGPT also uses language that is easy to understand"

"Very quick to provide answers and the sentences are easy to understand"

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

"Very influential on my learning process, because it is very helpful and provides material that is easy to understand"

The biology pre-service teachers also said that the use of ChatGPT is very easy, in accordance with the previous Likert analysis. Some examples of student responses are provided below:

"Easy to use and easy to access"

"The impression is easy to use, quite helpful for understanding because the sentences are easy to understand, brief, and clear"

"Very helpful, because the material presented is quite summarized but quite complete, it is also easy to use"

The pre-service biology teachers also mentioned that ChatGPT was very helpful to them, through its ability to summarize the material and provide immediate answers that were relevant to what they were asking. Here are some examples of responses from students about this:

"This tool can provide an overview of answers, learning materials quickly, briefly, and allows us to understand more easily."

"This tool can help simplify material or information that was previously difficult to understand. And this tool can help find other related material or information"

"ChatGPT is actually quite helpful in finding learning materials, it makes it easier to find materials"

In the second question, respondents were asked to compare their learning experience using ChatGPT with other learning resources such as textbooks, learning videos, or other online platforms). For the advantages of ChatGPT itself, they stated that ChatGPT provides more in-depth information than what is in the book. The following are some examples of student responses:

"I can access more in-depth information that I don't know in the book"

"It is very helpful to match the material when I get it in the book or text, ChatGPT provides more detailed material on the material that I get in the book or text"

According to the pre-service biology teachers, ChatGPT was very good at providing quick and concise answers, just as they requested. A few examples of student responses are provided below:

"ChatGPT is faster and more efficient in helping answer questions"

"The advantages of ChatGPT can be accessed anytime, very effective and efficient, the material described is also quite easy and understandable"

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

"Helps in understanding because it is concise and clear"

"ChatGPT provides faster learning in short and easy to understand, other sources are still often difficult to understand because they are quite long"

Not only that, ChatGPT also responds like a human response, and adapts to its use, so that it can provide answers that are easy to understand. The following are examples of student responses:

"I think finding answers with other sources is a bit difficult to understand, while when using ChatGPT I understand more easily because ChatGPT uses the language we often use, so it is easy to understand."

They also mentioned the disadvantages of ChatGPT compared to other learning platforms, for example, ChatGPT cannot provide images or reference sources for learning materials. Here are some examples of how students responded:

"It does not provide sources and illustrations"

"The disadvantage is that it does not provide sources and illustrations"

"The disadvantage of ChatGPT is that it is less difficult to trust, because it does not include journal or book sources"

"Disadvantages cannot display images, must use the internet or a good network"

Some pre-service biology teachers also complained about the technical and network constraints that occur when using ChatGPT. Below are examples of responses from students:

"The disadvantages are network constraints and sometimes ChatGPT often errors"

"The disadvantage is that my ChatGPT is often slow and has errors"

"The disadvantages are sometimes errors, cannot be used, and the network does not support"

"The disadvantage is that if there is no internet quota, it cannot be used"

Then for the next question, after using ChatGPT whether respondents felt easier to do assignments or understand the subject matter, respondents were asked to tell their experiences. Biology pre-service teachers conveyed positive responses and told how easy and direct responses made it easier for them to learn. These are a few samples of student replies:

"Yes, it is easier, because with ChatGPT I find it easier to understand the material, the explanation is short but easier to understand and very helpful when I am struggling"

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P-ISSN 0852-1190 E-ISSN 2502-0781

"After using ChatGPT it will be easier to understand because ChatGPT will provide answers that are easy to understand and can also make it easier for us to find answers or others."

"It is easy because it looks for answers, additional material, specific in-depth information and facilitates our understanding of a material"

"It is easier to understand the material because it presents material that is easy to digest and presents concise material not with language that is too heavy"

There were also pre-service biology teachers who expressed their concerns about ChatGPT, for fear of dependence. The following illustrate student responses:

"When I first started using ChatGPT, I was a little afraid because the use of AI will certainly have an impact, especially on myself who is dependent on using AI in all situations. But the hope is also that with the existence of ChatGPT, it can be used properly, and not forget the knowledge in books, journals, or other learning sources"

Discussion

Based on statistical tests, it is evident that the answering speed of the ChatGPT-treated group was faster than the control group. This result could be because ChaGPT helps users to get access to information faster and easier, compared to the information provided by Google, which provides information referring to certain websites (Chinonso et al., 2023). Previous research also revealed that, compared to Google, ChatGPT provides more relevant responses to questions (Hristidis et al., 2023). The ease of information obtained through ChatGPT, most likely causes respondents, in this case, biology pre-service teachers who study biochemistry material, to be easier to understand the course. Thus, the ease of information obtained by pre-service teachers causes them to remember answers more quickly when taking exams (Mehring & Thomson, 2016). This is also supported by previous research which states that ChatGPT can improve student learning through personalized tutoring mechanisms, interactive learning, and is able to translate source material into various languages so that it can reach many participants (Baidoo-Anu & Owusu Ansah, 2023). ChatGPT is also able to provide the same results when we slightly change the wording of our questions (Zhai, 2023). ChatGPT's genuine and captivating interactions with customers stem from its capability to grasp the significance of statements and phrasing (Gill & Kaur, 2023). This shows that ChatGPT has a strong ability to organize and structure article components, including in terms of providing answers that are easy to understand for pre-service biology teachers. Previous research on AI and Biochemistry has also shown a positive relationship, such as AlphaFold which has been shown to improve efficiency and accuracy in various biochemical applications (Jumper et al., 2021). Here we can see that ChatGPT is also able to increase the efficiency of the learning speed of biology pre-service teachers in biochemistry courses, making it easier for them to absorb information so that the material learned is easier to remember and faster to think about when answering questions about biochemistry.

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

As for the accuracy results, although the average score of class A (ChatGPT) was higher than class B, the statistical test showed that the results were not significantly different. This suggests that although ChatGPT provides the convenience of delivering material directly (Chinonso et al., 2023) , the information and knowledge of prospective teachers from classes using ChatGPT with classes using conventional sources such as Google websites, is not significantly different. This is different from previous research, which revealed that Chatbox has the potential to improve student learning outcomes (Winkler & Soellner, 2018). This could be due to ChatGPT obtaining information by gathering information from the internet (Ulusoy et al., 2023), which can also be accessed by classes using conventional searches. Since the sources of information provided by both ChatGPT and conventional search engines such as Google are the same, the information possessed by both groups of pre-service teachers is also the same. In addition, ChatGPT also has the disadvantage of including the source of the material, Google more often provides reliable dates and sources of responses compared to ChatGPT (Hristidis et al., 2023). Therefore, ChatGPT is highly recommended as a learning tool, but it cannot fully replace the role of the teacher or other sources of information.

On Likert analysis related to how effective ChatGPT is in supporting learning, it was formulated that respondents agreed with the statement that ChatGPT helps learning effectively. From the answers to open-ended questions, biology pre-service teachers also mentioned ChatGPT's ability to provide quick answers and to translate the material into easy-to-understand language, which really helped them in learning. Examples of answers related to this are *"Very quick to provide answers and the sentences are easy to understand"*, and *"This tool can help simplify material or information that was previously difficult to understand, and with this tool can help find other related material or information".* This is supported by previous research which suggests that ChatGPT could provide direct answers to questions asked (Chinonso et al., 2023). With direct answers and in context with customer questions (Hristidis et al., 2023), which makes ChatGPT is effective and can facilitate pre-service biology teachers in learning. This is also supported by previous research which revealed that ChatGPT has the possibility to substitute the role of conventional search engines which require a very long scanning time to find accurate and reliable information. ChatGPT offers an alternative to provide simple results that can be generated as many times as desired by the user (Alafnan et al., 2023). The effectiveness of ChatGPT is supported by its ability to explain personally (Baidoo-Anu & Owusu Ansah, 2023; Nazir & Wang, 2023), as well as the ability to understand and compose impressive words (Gill & Kaur, 2023; Zhai, 2023), so that customers can easily understand the answers given by ChatGPT. This is also in accordance with the answers given by pre-service biology teachers, who mentioned that ChatGPT was able to explain the material in a language that was easy for them to understand, *"It is easier to understand the material because it presents material that is easy to digest and presents concise material not with language that is too heavy"*. With the excellent effectiveness of ChatGPT, it is also positively correlated with the speed of answering prospective biology teachers in class A (ChatGPT). This outcome demonstrates that ChatGPT is highly effective and can enhance the quality of learning.

The Likert analysis also measured how easy ChatGPT is to use for learning. From the analysis, pre-service biology teachers strongly agreed that ChatGPT is easy to use for learning. Using ChatGPT is quite simple. The key requirement is that when participants

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

have a ChatGPT account, they can create chats or ask questions directly without needing to follow any specific formulas (Kalla & Kuraku, 2023). ChatGPT access is not complicated and can be used directly through the participant's smartphone, making it easier for participants to access ChatGPT. We can see this from the answers of pre-service biology teachers who said *"The advantages of ChatGPT can be accessed anytime, is very effective and efficient, and the material described is also quite easy and understandable"*. This is also supported by previous research that reveals how ChatGPT can generate human-like responses and can help students understand concepts they struggle with through customized and interactive explanations(Kalla & Kuraku, 2023). In addition, ChatGPT's ability to compose words that are easy to understand also makes it easier for pre-service biology teachers to use ChatGPT (Gill & Kaur, 2023; Zhai, 2023).

Likert analysis was further conducted to understand the impact of ChatGPT on biology pre-service teachers' learning motivation. Based on the Likert analysis, respondents agreed that ChatGPT had a great impact on their learning motivation. ChatGPT can be used at any time and can be a learning companion for pre-service biology teachers, when they have difficulties, they can ask directly to ChatGPT. Some examples of students answer related to this are *"Yes, it is easier, because with ChatGPT I find it easier to understand the material, the explanation is short but easier to understand and very helpful when I am struggling"*, and *"The advantages of ChatGPT can be accessed anytime, very effective and efficient, the material described is also quite easy and understandable".* This is also supported by previous research which found that ChatGPT provides interactive learning that can increase learning motivation (Dilzhan, 2024; Songsiengchai et al., 2023; Zhou & Li, 2023). Although the accuracy results did not significantly improve the pre-service teachers' learning outcomes, the increase in motivation could boost their enthusiasm and motivation to learn, leading to a significant increase in their responses. This proves that the integration of ChatGPT into education is increasingly necessary, especially to increase the learning motivation of prospective teachers and students in general. In addition, ChatGPT's ability to compose words that are easy to understand also makes it difficult for pre-service biology teachers to use ChatGPT (Zhou & Li, 2023)

Furthermore, the results of the Likert analysis also show that pre-service biology teachers agree that they were often constrained by technical problems when using ChatGPT. This aligns with their responses to the open-ended question, where they mentioned experiencing frequent errors and signal interference when using ChatGPT. For example, one participant noted, "*The disadvantages are sometimes errors, cannot be used, and the network does not support*," while another stated, "*The disadvantages are network constraints and sometimes ChatGPT often errors*". This was also found in previous research, which found internet challenges in the use of AI in learning (Zhai, 2023). The research recommends the importance of good internet facilities, to support AI-based learning in education. In addition, the importance of mentoring by teachers when students use AI in the classroom is very necessary (Zhai, 2023). So that if there are obstacles, the teacher can help what is a student's obstacle, both academically and technically when using ChatGPT.

In this research, we also found some findings such as obstacles or limitations felt by pre-service biology teachers when using ChatGPT. Some participants highlighted the shortcomings of ChatGPT, particularly its inability to include sources or create images. For instance, one participant mentioned, "*It does not provide sources and illustrations*,"

DOI: https://doi.org/10.17509/e.v24i2.76844
P-ISSN 0852-1190 E-ISSN 2502-0781

and another stated, "*The disadvantage is that it does not provide sources and illustrations*". But recently, OpenAI has updated ChatGPT, so that ChatGPT, especially ChatGPT marketplaces that have specialized ChatGPT with the ability to include references or generate images, is now accessible to anyone for free (OpenAI, 2024). Additionally, using ChatGPT requires reliable internet access, which can be challenging without an internet plan or with a poor signal. For example, one participant noted, "*Disadvantages include not displaying images and requiring a good internet connection*," while another mentioned, "*The disadvantage is that it cannot be used without an internet quota*". Another noteworthy observation is that some pre-service biology teachers expressed concerns about becoming overly reliant on AI. One student shared, "*Initially, I was apprehensive about using ChatGPT because dependence on AI can have significant implications, especially for someone like me who relies on AI in various situations. However, I also hope that ChatGPT can be utilized appropriately, without overshadowing knowledge gained from books, journals, or other educational resources*". Previous research tried to analyze the effect of ChatGPT on the level of laziness of students in doing assignments and showed that there was no statistically significant effect either before or after using ChatGPT (Alya Resti Saraswati et al., 2023). However, the anxiety felt by these pre-service biology teachers is a valid feeling, which needs to be considered by policymakers. Lecturers and teachers need to prepare careful regulations to prevent the potential negative influence of ChatGPT (Jafar Maulana & Darmawan, 2023).

4. CONCLUSION

Investigation of the effect of ChatGPT on the response speed and accuracy of learning outcomes of pre-service biology teachers in biochemistry and analysis of their perception of ChatGPT have been conducted in this study. Our study showed that ChatGPT was able to increase the response speed of biology pre-service teachers, but did not provide different learning outcomes from the group of pre-service biology teachers who used conventional search engines in biochemistry courses. The speed of answering pre-service biology teachers can increase, which can be caused by ChatGPT providing answers that are direct and relevant to the questions asked by visitors The ease with which information is obtained can increase the chances of it being recalled quickly when taking exams. However, the class using ChatGPT did not differ from the conventional class in terms of accuracy of learning outcomes, which could be due to the information or material used by both, coming from the same reference source. This gives us new knowledge, that ChatGPT's ability to provide explanations that are easy to understand, so that it can increase the chances of responding to the speed of answering participants. ChatGPT has also proven to be effective and very easy to use by pre-service biology teachers, as a tool in learning. However, there are some challenges faced by pre-service biology teachers when using ChatGPT, ranging from signal constraints to sometimes ChatGPT experiencing errors. This research also proves that the role of ChatGPT is not to replace the role of teachers or other learning resources, but ChatGPT is here to improve learning efficiency, by collaborating with other reference sources to complement and strengthen the effectiveness of learning. In addition, there are also concerns from pre-service biology teachers, regarding the reliance on ChatGPT especially in the world of education. This shows the importance of policy makers and educators, to be able to immediately make appropriate and effective policies, to be able to maximize the potential of ChatGPT and prevent the negative effects of ChatGPT in the world of education. Recommendations for future research can test the effectiveness of ChatGPT in other

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subject areas, especially courses that require in-depth mathematical analysis, to see the ability of ChatGPT to explain numerical material. In addition, it is necessary to analyze the laziness and enthusiasm for learning of students or pre-service teachers who have used ChatGPT in the long term. It is important to see how ChatGPT affects the long-term careers of its students, to be able to be important information, supporting the progress of better education

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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DOI: https://doi.org/10.17509/e.v24i2.76844
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