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The effectiveness of microteaching to enhance prospective teachers' skills in guiding inquiry through student questioning

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ABSTRACT

This study aims to analyse the effectiveness of microteaching strategies in enhancing the ability of prospective biology teachers to handle student questions to promote inquiry-based learning. The research method used a one-group pretest-posttest design involving 21 students from the Biology Education Study Program. Data were collected through microteaching assessment instruments and statistically analysed using the Paired Samples T-Test. The research results show a significant improvement ($p < 0.05$) in all aspects of question-handling skills, including the accuracy of responding to questions (pretest: 87.19; posttest: 90), guiding students to think inquiry (85.19 to 89.43), assisting in identifying variables (87.18 to 89.43), and formulating research questions (86.62 to 89.43). The average posttest score (89.66) was higher than the pretest (87.12) with a lower standard deviation (0.56 vs 2.16), indicating consistent achievement of competence. The main constraint lies in the tendency of prospective teachers to dominate the question-and-answer sessions and the difficulty in guiding the formulation of inquiry questions. This study recommends the integration of microteaching into the biology teacher education curriculum, with an emphasis on question scaffolding techniques and systematic feedback. The implications of this research support the development of pedagogical skills in prospective biology teachers in implementing inquiry-based learning.

INTRODUCTION

This research aims to analyse the effectiveness of the strategy microteaching is a valuable technique for enhancing pedagogical skills among prospective teachers, especially in the context of inquiry-based learning in biology education. Several studies highlight its effectiveness and provide insights into how it can be applied to address student questions and promote inquiry-based learning (St James & Campbell, 2020). The microteaching model has proven effective in enhancing the teaching skills and knowledge of biology education students. Students responded positively to this model, indicating that it enhances their ability to manage classroom interactions and student questions effectively (Spaan et al., 2025). However, limited research has examined how microteaching specifically improves prospective biology teachers' competence in handling student questions to support inquiry-based learning.

Through microteaching, prospective teachers can receive direct feedback, reflect on their practices, and develop better teaching strategies in a controlled and supportive environment . The application of microteaching designed contextually and emphasising active learning, such as inquiry-based learning, has the potential to enhance the professional readiness of prospective teachers in facing the dynamics of real classrooms (Damopolii et al., 2021).

The microteaching technique significantly improves presentation skills, including the ability to provide non-verbal cues and clearly state objectives. This is very important for handling student questions and facilitating inquiry-based learning, as it helps teachers present information in a way that encourages student engagement and curiosity (Wilson et al., 2025). Handling effective questions is an important component of inquiry-based learning. However, many prospective biology teachers struggle to apply questioning strategies that facilitate student inquiry. Training in micro-teaching can help teachers develop these skills, although more emphasis is needed on scaffolding student questions throughout the inquiry process (Chengere et al., 2025).

Furthermore, Microteaching for prospective teachers is important to be able to Handle Student Questions to Encourage Inquiry-Based Learning. Inquiry-based learning is a teaching strategy that emphasises student-driven exploration and collaborative learning (Herranen & Aksela, 2019), aiming to foster deep understanding and scientific reasoning (Shiau et al., 2024). Inquiry-based learning is recognised as an effective approach in biology education, promoting deep understanding and scientific reasoning. Microteaching can support this by helping teachers improve their questioning techniques and guiding students through the inquiry process (Talavera-Mendoza et al., 2024).

Although it has benefits, prospective teachers often face challenges such as large class sizes and limited resources, which can hinder the effective implementation of inquiry-based learning. Training programs must address these challenges by providing strategies for managing large classes and ensuring adequate resources (Talavera-Mendoza et al., 2024). When a student asks a question, the teacher has three strategic options: (1) answer directly, (2) invite another student to respond, or (3) direct the question for further development.

When a student asks a question, the teacher has three strategic options: (1) answer directly, (2) allow another student to respond, or (3) direct the question for further development. This third option is particularly important in inquiry-based learning, as the teacher can guide students to: (a) think independently until they find the answer, or (b) reformulate their question into one that can be scientifically investigated. The skill of asking questions that trigger inquiry is an essential competence in Science/Biology, because without open and structured questions, the investigation process will not occur. Unfortunately, many students struggle to formulate such questions. This is where the strategic role of the teacher is needed. Teachers can help students by: (1) guiding them to transform ordinary questions into investigative questions, (2) identifying researchable variables, and (3) formulating questions that allow for experiments or observations (Widodo et al., 2025).

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The teacher's strategy for handling student questions is by collecting and developing questions. Students trained in microteaching showed significant improvement in presentation skills, including providing non-verbal cues and clearly stating objectives (Librea-Carden et al., 2021). The teacher needs to skilfully gather and develop students' ideas and questions. This involves creating a classroom environment where students feel comfortable asking questions and engaging in scientific discourse (Herranen & Aksela, 2019). Teachers must guide students in refining their questions from vague to complex, ensuring that the inquiry process is student-centered and takes place over an extended period (Spaan et al., 2025). Shifting from teacher-centered questions to student-centered questions involves focussing on student questions rather than teacher questions, and assessing these questions to support higher-order thinking (Talavera-Mendoza et al., 2024).

The reality in the school, teachers often find it difficult to help students develop their questions into meaningful investigations. This challenge is exacerbated by the need for specific discourse strategies to effectively attend to students' thinking (Herranen & Aksela, 2019). Ongoing professional development programs are crucial for equipping teachers with the skills needed to effectively implement these strategies. These programs should focus on enhancing content knowledge, pedagogical strategies, and teacher confidence (Furman et al., 2019).

Teachers should use open-ended questions that stimulate higher-order thinking, such as analysing, synthesising, and evaluating, to support students' enquiries (Wang, et al., 2024). Providing feedback and explanatory support during the investigation process helps students critically analyse results, draw conclusions, and discuss broader implications (Strat et al., 2024). Teachers should integrate questioning techniques that encourage investigative discourse, support metacognitive regulation, and bridge the gap between high and low-achieving students through collaborative learning (Severini et al., 2024).

Teachers must integrate questioning techniques that encourage inquiry discourse, support metacognitive regulation, and bridge the gap between high and low-achieving students through collaborative learning (Al-Nofaie & Alwerthan, 2024). The inquiry approach in biology learning is essential for fostering a deeper understanding of scientific concepts, enhancing student engagement, and developing critical scientific skills (Apriliana & Purwianingsih, 2018). Its adaptability and effectiveness across various educational contexts make it a valuable strategy for modern biology education (Maeng et al., 2020). Developing curriculum tools that include examples of effective discourse moves can help teachers manage and encourage student questions more effectively in the classroom (Wang, et al., 2024). This study aims to evaluate the effectiveness of microteaching in preparing prospective biology teachers to handle student questions in biology education. Although previous research has established the general benefits of microteaching in teacher preparation, few studies have investigated how it specifically enhances prospective biology teachers' questioning strategies within inquiry-based learning contexts. Moreover, little attention has been given to how microteaching can be used to scaffold the development of student-generated questions using structured frameworks such as the Questioning-Based Inquiry Cycle (QBIC).

METHODS

The type of research used in this study is pre-experiment. This study uses a one-group pretest-posttest design to measure the effectiveness of microteaching intervention in improving prospective biology teachers' skills in handling student questions. This design is used because there is a pretest before the treatment is given, and the treatment results can be known more accurately because they can be compared with the state before the treatment. This design can be illustrated as shown in Table 1 below:

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Table 1. One-group pretest-posttest design

Pretest	Treatment	Posttest
O1	X	O2

Notes:
O1 = Pretest score of the initial ability of prospective teachers in responding to student questions (through teaching simulation).
X = Treatment by applying microteaching experience with a focus on strategies for responding to student questions and feedback from the team lecturer.
O2 = Posttest score by re-evaluating the microteaching ability of prospective teachers using the same instrument).

This research was conducted with prospective Biology teachers. The population in this study consists of 21 Biology Education fifth-semester student. The sampling was conducted using the simple random sampling technique, considering that the students' positions in the class were assigned randomly without regard to their grades, gender, or student groups. The instrument used in this study is the microteaching evaluation instrument. The instrument is used as an evaluation tool to collect data on the testing method, which in this case is the pretest and posttest. Data analysis uses statistical tests (Paired Samples T-Test) to see significant improvements.

RESULTS AND DISCUSSION

Based on the one-group pretest-posttest research design that has been conducted, the data obtained provides a comprehensive picture of the effectiveness of the microteaching strategy in improving the ability of prospective biology teachers to handle student questions. This analysis aims to measure the extent to which the microteaching strategy can enhance the competence of prospective biology teachers in managing student questions to promote inquiry-based learning, while also observing the consistency of improvement across all students. The presented statistical data will be analysed in more depth to understand the real impact of the microteaching intervention provided. This can be seen from Table 2, which compares the pretest and posttest results of the research sample depicted in the table below.

Table 2. Statistical analysis of pretest-posttest results

Data Type	Pretest	Posttest
N	21	21
Mean	87,12	89,66
Standard deviation	2,16	0,56
Min	79	84
Max	90	90
Paired Samples T-Test	0,000 Significant	

Based on the data presented in Table 1, there is a significant improvement in the prospective teachers' ability to handle student questions after participating in microteaching. The pretest results showed an average score of 87.12 with a standard deviation of 2.16, while the posttest increased to 89.66 with a lower standard deviation (0.56). This indicates that not only was there an increase in the average score, but also the consistency of the participants' abilities became more uniform after the intervention. The results of the Paired Samples T-Test with a significance value of 0.000 ($p < 0.05$) further strengthen the notion that microteaching has a statistically significant impact on improving the skills of prospective teachers. This means there was an increase in the

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implementation scores of microteaching after the treatment by applying microteaching experiences with a focus on strategies for responding to student questions and feedback from the lecturer team.

This improvement is in line with the findings of (Pedaste et al., 2015), which state that microteaching effectively trains prospective teachers to transform simple questions into investigative questions in biology. The decrease in standard deviation from 2.16 to 0.56 also indicates that microteaching successfully reduced the variation in abilities among participants, so that most prospective teachers achieved an adequate level of competence. These findings support the need for integrating microteaching into teacher education curricula, particularly to optimise inquiry approaches through more effective handling of student questions.

When a student asks a question, the teacher has three strategic options: (1) answer directly, (2) invite another student to respond, or (3) guide the question for further development. This third option is especially important in inquiry-based learning, as the teacher can guide students to: (a) think independently until they find the answer, or (b) reformulate their question into one that can be scientifically investigated. The skill of asking questions that trigger inquiry is an essential competence in Biology, because without open and structured questions, the investigation process will not occur. Unfortunately, many students struggle to formulate such questions. This is where the strategic role of the teacher is needed. Teachers can help students by: (1) guiding them to transform ordinary questions into investigative questions, (2) identifying researchable variables, and (3) formulating questions that allow for experiments or observations (Widodo et al, 2025).

Figure 1 presents a visual comparison between pretest and posttest scores for five aspects of handling student questions skills developed through microteaching strategies. This image clearly visualises the development of the competencies of prospective biology teachers in various types of question-handling skills, ranging from the accuracy of responding to student questions to the ability to guide the formulation of research questions.

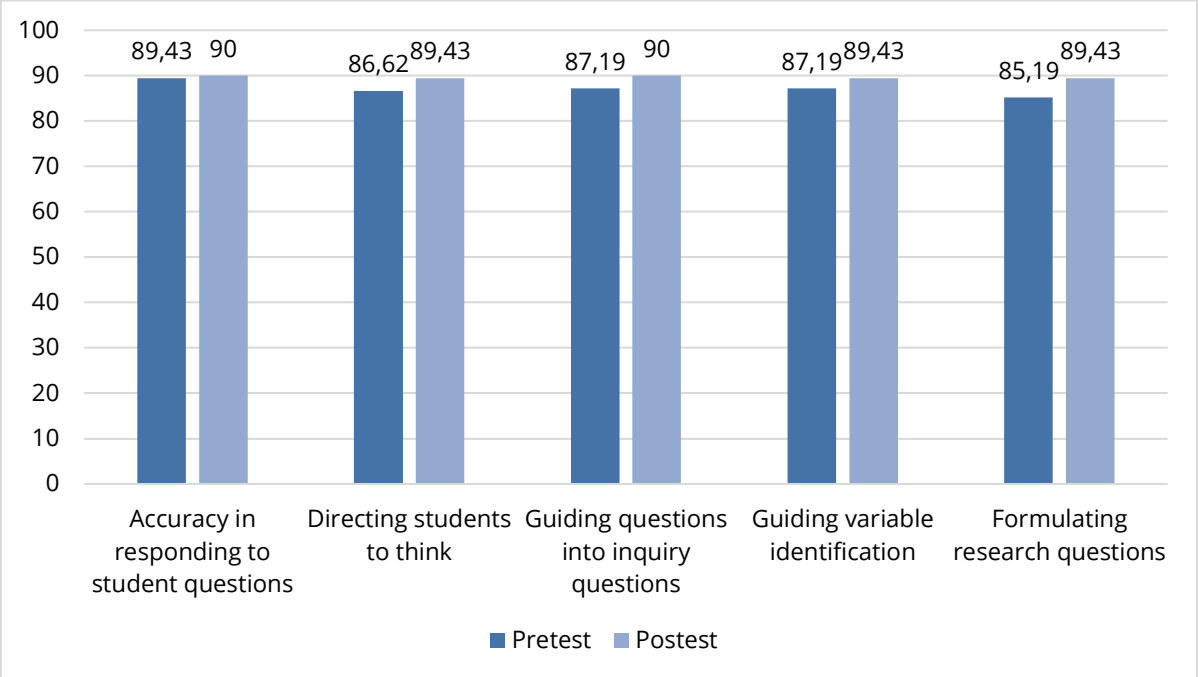

Figure 1. Graph of values of types of skills handling student questions

Based on Figure 1, it clearly shows a significant improvement in all aspects of handling student questions after the microteaching intervention. The microteaching approach is effective in developing the pedagogical competence of prospective teachers, particularly in handling student questions. All indicators showed an increase in scores from pretest to posttest, with the

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highest improvement observed in the aspects of "guiding students to think inquiry" (from 85.19 to 89.43) and "guiding variable identification" (from 87.18 to 89.43). It means that the prospective teachers' skills in guiding inquiry through student questioning have improved from the good category to the very good category. These findings support the research on the effectiveness of microteaching in developing inquiry question skills (Hiltunen et al., 2020).

The posttest scores for all indicators ranged from 89.43 to 90, indicating relatively uniform achievement. This is consistent with the report by Hiltunen et al., (2021) on the ability of microteaching to standardise pedagogical competence. the ability to "respond accurately to student questions" achieved the highest score in both the pretest (87.19) and posttest (90). These findings reinforce the argument (Yi et al., 2023) about the importance of content mastery before developing higher-order questioning skills. The aspect of "guiding the formulation of research questions" showed an increase from 86.62 to 89.43, indicating that this complex skill requires more practice, as revealed in the study by (Wang et al., 2024).

As for the examples provided by the students, most of the students responded correctly to the students' questions, but some students still did not fully grasp the concepts, so when the prospective teachers responded to the students' questions, their responses were not accurate. On the point of guiding students to think, most students have guided students to think, but there are some prospective teachers who ask too many questions, which lessens the students' opportunity to think. In the skill of guiding questions into inquiry questions, most prospective teachers already possess this skill, but there are still some prospective teachers who give students the opportunity to develop their inquiry abilities. In the type of skill guiding variable identification, most prospective teachers have acquired this skill, but there are also teachers who do not direct the skill of guiding variable identification. In the type of skill of formulating research questions, most prospective teacher students already possess this skill, but there are still some prospective teacher students who need to further develop their ability to formulate research questions (Vígh, 2024). Based on the data, microteaching has proven effective for all aspects of question handling, but more emphasis is needed on the skill of guiding the formulation of research questions.

Accuracy in responding to student questions

The accuracy in answering student questions is a complex issue that involves various factors such as questioning methods, student confidence, feedback mechanisms, and technological interventions. The design and difficulty level of questions play an important role in accurately measuring students' competence. Questions must be balanced in difficulty levels to effectively differentiate between students with varying abilities. (Furman et al., 2019). Students' confidence in their answers significantly affects the accuracy of their responses. Some students during the microteaching practice still lack confidence, such as tending to be silent at the beginning of the microteaching and some students still tend to read rather than explain.

The depiction of prospective teacher students shows that most have mastered the skill of accuracy in responding to student questions, but some students have a poor understanding of concepts, which leads to incorrect responses to students' questions. Like students who are less accurate in explaining the concepts of blood types, photosynthesis, viruses, cells, the reproductive system, the environment, genetics, animalia, plantae, and metabolism. So when prospective teacher students have not mastered a concept, they will not respond accurately to students' questions.

Students' confidence in their answers significantly affects the accuracy of their responses. Too much confidence can lead to inaccuracy, while methods to reduce confidence, such as asking students to explain their answers, can improve accuracy. Providing accurate and detailed feedback can improve students' performance in answering questions and their ability to assess the relevance of the text (Shiau et al., 2024). AI-powered systems and audience response systems (ARS) can improve response accuracy by providing immediate feedback and engaging students

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interactively. AI systems have demonstrated high accuracy in generating relevant responses and improving learning outcomes (Wang et al., 2024).

In addition, in the microteaching practice, the prospective teachers ask more questions and the students answer, which gives less opportunity for the students to ask questions. The lecturer provided feedback to reduce the explanation phase so that students have the opportunity to ask questions. Additionally, prospective teachers still tend to explain a lot; it would be better to immediately direct them to encourage students to ask questions. There are several unanswered questions regarding the explained concept (Purwianingsih & Mardiyah, 2018).

The accuracy of feedback is very important. Inaccurate feedback can delay task acquisition and negatively impact learning outcomes. Accurate and formative feedback is crucial for effective learning (Yi et al., 2023). Improving the accuracy of responses to student questions involves a combination of well-designed questions, confidence assessments, accurate feedback, and technological interventions (Sagban et al., 2021). AI and ARS systems offer promising solutions to enhance accuracy and engagement, but careful consideration of feedback mechanisms and student characteristics is crucial for optimal outcomes.

Directing students to think

The next type of skill is guiding students to think. Prospective teachers effectively guide students to think critically and engage deeply with the material; several strategies can be applied. These strategies focus on creating an environment that encourages inquiry, reflection, and active participation. Encouraging students to explore concepts by asking open-ended questions that require answers beyond just yes or no. This encourages critical thinking and allows students to express their thoughts and reasoning.

In this type of skill, there are still many prospective teachers who ask too many questions. it should start from the students' questions, then guide the students to think. Additionally, the questions that have already been asked by the students are asked repeatedly. Some prospective teachers also still lack in guiding students to think. To anticipate this, the Socratic questioning technique can be used to challenge students' assumptions and encourage deeper analysis. Questions that delve into clarification, explore implications, and request evidence can stimulate critical thinking. Apply the think-pair-share technique, where students first think about a question individually, then discuss their thoughts with a partner before sharing them with a larger group. This method encourages collaboration and reflection.

The next obstacle is that the teacher asks questions that are too broad. So, students are less involved in problem-based learning scenarios where they have to apply their knowledge to solve real-world problems. This approach encourages critical thinking and helps students see the relevance of their learning. Incorporate reflection activities, such as journals or group discussions, where students can express their thoughts and feelings about what they have learnt. Reflection helps reinforce understanding and encourages metacognition.

Student thinking guidance is still underexplored. Students can be encouraged to create analogies or metaphors related to the material. This can help them connect new concepts with prior knowledge and think creatively about the subject matter. Utilise technological tools, such as interactive simulations or online discussion forums, to engage students in active learning. Technology can provide diverse perspectives and resources that stimulate critical thinking (Yi et al., 2023).

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Guiding questions into inquiry questions

In the context of guiding questions into inquiry questions, it is important to focus on deepening the investigation process, encouraging exploration, and promoting critical thinking. Guiding questions often yield simple answers. Change them into open-ended questions that require explanation, analysis, or evaluation.

An example of the actions of prospective teacher students is most students have mastered the skill of guiding questions into inquiry questions. However, there are challenges faced by prospective teacher students, one of which is not directing students to ask inquiry questions. Teachers still ask inquiry questions that give students fewer opportunities to develop their inquiry skills, and the inquiry questions created by prospective teachers are still lacking. Feedback on the challenges faced by prospective teacher students includes creating questions that encourage students to explore various perspectives, contexts, or implications of a topic. Use "how" and "why" to encourage deeper thinking and understanding of the principles or reasons underlying a concept. Connect the questions with real-world scenarios or problems, encouraging students to consider the relevance and application of their learning. Include questions that ask students to reflect on their own experiences, beliefs, or assumptions related to the topic (Máñez et al., 2019).

Transforming guiding questions into inquiry questions involves deepening the inquiry process by creating open-ended questions, encouraging exploration, and connecting with real-world issues. By using these strategies, educators can foster a more engaging learning environment and provoke thinking that supports critical thinking and inquiry-based learning (Spaan et al., 2025).

Guiding variable identification

Type of skill Guiding variable identification is an important skill that affects study design, data collection, and analysis. Operationalising variables involves defining them in a way that allows for accurate measurement. This includes determining how each variable will be measured and ensuring that the measurement methods are reliable and valid.

An example of the actions of prospective teacher students in the skill type of guiding variable identification is that most prospective teacher students have mastered this skill. However, the constraint faced by prospective education students in this type of skill is that it should be the students who identify the variables, but here the teacher is the one identifying the variables. It would be better if students' answers to investigative questions were recorded so that they could guide students in identifying variables. Some prospective teacher students still explain variable identification; students should learn to identify variables.

Feedback on such skill-related constraints is to use steps to identify variables. For example, by determining the research objectives: the teacher clearly explains the questions and research objectives to identify which variables are needed to answer them. The teacher provides clear conceptual definitions for each variable to avoid ambiguity. The teacher determines how each variable will be measured, including the units of measurement and the tools or instruments used. Additionally, the teacher specifies whether the variables are independent, dependent, confounding, moderating, or extraneous (Wang et al., 2024). Choose the appropriate scale to measure the variable (nominal, ordinal, interval, ratio) (Novidsa et al., 2021). Identify potential confounding variables and plan ways to measure and adjust for them in the analysis (Andrade, 2021). By following these guidelines, researchers can effectively identify and classify variables, ensuring that their studies are well-designed and their findings are robust and replicable.

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Formulating research questions

The next type of skill is formulating effective research questions, which is an important step in the inquiry learning process, as it directs the study's direction and helps focus the investigation. Some challenges faced by prospective teacher students include the need to further develop their ability to formulate research questions. Teachers do not write down student questions that lead to inquiry for variable identification and research question formulation. Research questions are still formulated by the teacher; ideally, the teacher should only act as a guide, and the students should be the ones formulating the research questions.

Strategies for Formulating Research Questions can start with a Broad Topic. Starting with a general area of interest and narrowing it down to specific aspects that are appealing to students. Review the literature to find areas that are underexplored or where conflicting results exist. Can use the PICO Framework: For health-related research, consider using the PICO framework (Population, Intervention, Comparison, Outcome) to formulate questions Suganda et al., 2021).

The next step is to create open-ended questions that cannot be answered simply with "yes" or "no." This encourages deeper exploration and analysis. Consider that "Why" and "How" can lead to more comprehensive investigations and insights (Dobber et al., 2017). Make sure that your questions are clear and focused, avoiding vague language that could cause confusion. Align with the research objectives by ensuring that your question is in line with the overall goals of the research project to be conducted in the study. Formulating research questions involves starting with a broad topic, identifying gaps in existing research, and using frameworks like PICO for structure (Herranen & Aksela, 2019). By creating open, specific questions that align with the research objectives, researchers can formulate focused questions that effectively guide their studies. This process not only clarifies the direction of the research but also enhances the overall quality and relevance of the investigation.

CONCLUSION

Based on the research results that have been conducted, it can be concluded that the microteaching strategy is effective in improving the ability of prospective biology teachers to handle student questions to encourage inquiry-based learning. This is evidenced by a significant improvement in pedagogical skills. The results of the statistical analysis show a significant improvement ($p < 0.05$) in all aspects of question-handling skills, including the accuracy of responding to questions, guiding students to think critically, assisting in the formulation of inquiry questions, identifying variables, and formulating research questions. The average posttest score (89.66) was higher than the pretest (87.12) with a lower standard deviation (0.56 vs 2.16), indicating consistent achievement of competence.

The microteaching learning strategy for prospective teachers in handling student questions to encourage inquiry-based learning in biology can be integrated into the biology teacher education curriculum. However, in the future, training modules focused on inquiry question scaffolding techniques are needed. Systematic feedback from supervising lecturers, which has already been implemented in the application of this strategy, is also very important. The recommendation for further research is the need for a longitudinal study to measure the long-term impact of exploring the effectiveness of microteaching in a digital learning environment. Development of more comprehensive assessment instruments.

Overall, this research affirms that microteaching is a potential training strategy for preparing prospective biology teachers to implement inquiry-based learning through effective handling of student questions, in line with the demands of the 21st-century curriculum that focusses on the development of critical and scientific thinking skills.

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