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Exploring the readiness of pre-service biology teachers in designing inquiry-based practicum: An analysis of biology lesson plan

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ABSTRACT

Inquiry-based learning is widely acknowledged as an effective instructional approach to achieve these competencies by engaging students in independent investigation and scientific reasoning through practical experiences. However, limited research has examined the extent to which pre-service biology teachers are capable of designing practicum activities grounded in inquiry, particularly within the Indonesian context. This study aimed to evaluate the ability of pre-service biology teachers to design inquiry-based practicum lessons through an analysis of their lesson plans. A qualitative descriptive method was employed to explore the structure and quality of the lesson plans. The population consisted of undergraduate students enrolled in a biology education program at a public university in Indonesia. A total of 69 pre-service biology teachers participated as the sample, organized into 22 collaborative groups. Data were collected through documentation of the practicum lesson plans developed during coursework. These documents were analyzed based on predetermined criteria, including completeness, relevance, and alignment with the essential components of inquiry-based learning. The findings revealed that most pre-service teachers demonstrated proficiency in formulating learning objectives, integrating scientific process skills, and constructing assessment elements. However, significant deficiencies were identified in the elaboration of procedural steps and in the coherence of the inquiry phases implemented. These results highlight the necessity for enhanced pedagogical support and targeted training programs to strengthen procedural planning skills and deepen understanding of the inquiry-based learning model.

INTRODUCTION

Biology education in the 21st century faces increasing demands to prepare students for a rapidly changing world. As global challenges such as environmental sustainability, biodiversity loss, and scientific innovation become more complex, the need for students to develop Higher-Order Thinking Skills (HOTS), critical thinking, and Science Process Skills (SPS) has never been more urgent. These competencies enable students to approach problems scientifically, critically evaluate evidence, and make informed decisions. Within this context, inquiry-based learning has emerged as a cornerstone of effective science education, particularly in biology. The inquiry-based approach is widely acknowledged as a powerful pedagogical method that fosters active student engagement, enhances conceptual understanding, and develops critical thinking skills (Yunus, 2023).

Inquiry-based learning (IBL) emphasizes student-centered exploration, where learners actively participate in the process of scientific investigation. This includes formulating questions, designing and conducting experiments, analyzing data, and drawing evidence-based conclusions. According to Antonio and Prudente (2024), the inquiry approach has a significant positive impact on students' development of HOTS, regardless of their educational level or the degree of inquiry implemented. Similarly, Syahgiah et al. (2023) revealed that the inquiry model significantly enhances both SPS and critical thinking skills, further reinforcing its importance in modern education. In the context of biology education, practical laboratory activities hold immense potential to integrate inquiry-based methods. These activities allow students not only to learn biological concepts but also to experience firsthand how scientific knowledge is constructed (Samsuri & Fitriyani, 2016). Inquiry-based practicals encourage students to actively engage with the material, leading to deeper understanding and improved science process skills (Aprilia et al., 2020). However, the successful implementation of such activities relies heavily on the teacher's ability to design effective inquiry-based lesson plans that align with both pedagogical goals and curriculum standards (Sari et al., 2019).

While the benefits of inquiry-based learning are well-documented, its implementation is not without challenges. Teachers play a crucial role as facilitators in the inquiry process, and their ability to design and implement inquiry-based lessons is a key determinant of success. Research shows that pre-service biology teachers often face difficulties in designing inquiry-based lessons, particularly in formulating meaningful investigative questions, developing effective experimental procedures, and providing appropriate scaffolding for students during the inquiry process (Pratiwi & Lepiyanto, 2018). These challenges are compounded by gaps in teacher education programs, which frequently lack specific training on how to design and implement inquiry-based practical activities. According to Rusdiyana (2025), the current curriculum in teacher education programs often provides limited opportunities for pre-service teachers to develop the skills necessary for designing inquiry-based lessons. As a result, many pre-service teachers enter the workforce without the confidence or competence to effectively integrate inquiry into their teaching practice.

Most existing research has concentrated on in-service teachers who are already practicing in schools, or on the outcomes of inquiry-based learning for students. For example, studies by Samsuri and Fitriyani (2016) and Aprilia et al. (2020) primarily explore the impact of inquiry-based approaches on students' concept mastery and SPS. While these studies provide valuable insights, they do not address the competencies required by pre-service teachers to design such lessons. Despite the growing body of research on inquiry-based learning, there remains a significant gap in studies focusing on the readiness of pre-service biology teachers to design inquiry-based practicum lessons.

Biology education in Indonesia faces unique challenges, including large class sizes, limited resources, and varying levels of teacher preparedness. The integration of inquiry-based methods into biology instruction is further complicated by the lack of explicit training in teacher education programs. As noted by Hidayah and Imaduddin (2015), there is a pressing need for research that

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explores the specific skills and knowledge required by pre-service teachers to design inquiry-based practicum activities. Addressing this gap is essential to improving the quality of biology education in Indonesia and ensuring that future teachers are well-equipped to meet the demands of 21st-century science education. This study aims to fill the existing research gap by providing a comprehensive analysis of the readiness of pre-service biology teachers to design inquiry-based practicum lessons. Unlike previous studies that focus on the implementation of inquiry-based learning by experienced teachers, this research is unique in its focus on pre-service teachers. It specifically examines the components of inquiry-based practicum lesson designs that have been mastered and not yet mastered by pre-service biology teachers. The factors influencing their ability to design inquiry-based practicum lessons include pedagogical knowledge, content knowledge, and contextual factors such as curriculum constraints and resource availability. Recent studies have highlighted the importance of equipping pre-service biology teachers with the necessary competencies to design effective inquiry-based practicum lessons. For instance, Bwalya et al. (2023) found that implementing a TPACK-based technology integration course significantly enhanced pre-service biology teachers' technological pedagogical content knowledge, which is crucial for designing and implementing inquiry-based lessons effectively.

Furthermore, Abza et al. (2022) demonstrated that guided inquiry-based instructional models positively influenced pre-service biology teachers' attitudes towards invertebrate zoology learning, indicating the effectiveness of inquiry-based approaches in teacher preparation programs. The novelty of this study lies in its emphasis on the preparation phase of biology teachers, which is often overlooked in the literature. By focusing on pre-service teachers, this research provides insights into the foundational competencies required to effectively implement inquiry-based methods. Furthermore, it contributes to the state of the art in biology education by identifying specific areas where teacher education programs can be improved to better prepare pre-service teachers for the challenges of 21st-century science education. The primary objective of this study is to assess the readiness of pre-service biology teachers to design inquiry-based practicum lessons. To achieve this, the research aims to identify key competencies, analyze influencing factors, and develop recommendations, enhance teacher training curricula, support professional development, and contribute to the academic literature.

This study seeks to explore the readiness of pre-service biology teachers to design inquiry-based practicum lessons, addressing a critical gap in the literature and providing valuable insights for improving teacher education programs. By focusing on the competencies required for effective lesson design, this research is intended to enhance the preparation of future biology teachers, ensuring that they are well-equipped to meet the challenges of 21st-century science education. Through its emphasis on practical recommendations and its contribution to the academic literature, this study has the potential to make a meaningful impact on the field of biology education.

METHODS

This study employed a qualitative descriptive research design to explore the ability of pre-service biology teachers in designing inquiry-based practicum activities. The research subjects consisted of 69 pre-service biology teachers from Universitas Pendidikan Indonesia, who were enrolled in an Inquiry-based Lesson course and organized into 22 collaborative groups. The study was conducted in December 2024. Data were collected through documentation of lesson plans developed by each group as part of their coursework. These documents were analyzed based on criteria that included completeness, relevance to practicum objectives, and alignment with the fundamental principles of inquiry-based learning. The initial stage conducted in this research is the analysis of the Lesson Plan or Learning Design created by a pre-service Biology teacher. The primary data obtained are the results of the analysis of the Lesson Plan, while the secondary data

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are obtained from the literature review related to previous research that is still relevant to the topic of focus in this study.

The data collection technique was carried out by gathering Learning Design assignments from pre-service Biology teachers in the Inquiry Learning course using evaluation rubrics. After the assignments were collected, the data were written in the form of tables and presented in graphical form for further interpretation of the data. The results of the interpretation are then linked to previous research findings, leading to a research conclusion (Abdullah, 2018). The aspects analyzed in the Learning Design include the completeness of identity, learning outcomes, Science Process Skills (SPS), learning objectives, facilities and infrastructure, learning procedures, availability of Student Worksheets, Student Worksheet assessment guidelines, and the accuracy of assessments (alignment of assessments with learning outcomes).

RESULTS AND DISCUSSION

The results of this study refer to the data from the analysis of the Inquiry Learning Design (Lesson plan) created by students. The data is presented in Table 1.

Table 1. Data results of inquiry learning design analysis

Observed aspects	Analysis results
Identity Completeness	Contains all elements supporting the identity of the subject, such as educational level, grade, semester, subject name, main/sub-topic, and time allocation.
Learning Outcomes	The learning outcomes reflect alignment with the expected competencies and are relevant to the designed learning topics.
Science Process Skills	Covers all indicators of science process skills.
Learning Objectives	The objectives are aligned with the learning outcomes, ABCD elements, student characteristics, facts, concepts, principles, and subject matter details.
Learning Media	The learning media are aligned with the learning objectives and inquiry-based learning content.
Learning Procedures	The explanation of introduction, main, and closing activities is unclear and does not align well with inquiry-based learning or systematic model stages.
Availability of Student Worksheets	Includes the students' worksheet containing scientific process skills indicators, supporting the effectiveness of inquiry-based learning.
Worksheet Assessment Guidelines	Provides clear worksheet assessment guidelines that facilitate learning evaluation and ensure the achievement of learning objectives.
Assessment Completeness	The assessment is fairly comprehensive, covering knowledge, skills, and attitudes aligned with the learning objectives.
Assessment Accuracy (Alignment with Outcomes)	Includes assessments that are appropriate and aligned with the learning outcomes, supporting accurate competency measurement.

Based on the analysis of Table 1, the inquiry-based biology practical learning design, the analysis results were obtained in several aspects. The first aspect observed is the completeness of the learning design identity, which shows that the learning designs created by students mostly include all the important elements of the subject identity, such as educational unit, class, semester, subject, main material or sub-material, and time allocation. This indicates that the pre-service Biology teachers have paid attention to important administrative aspects in the preparation of learning devices. The second aspect is the learning outcomes. The lesson plan reflects alignment

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with the expected competencies and is relevant to the designed learning topic. This shows the understanding of pre-service biology teacher students regarding the relationship between the competencies to be achieved and the material to be taught.

The aspect of science process skills (SPS) is also an important aspect of the analysis in this research, because, in essence, inquiry-based learning can train the science process skills that students must possess. The analysis results show that the lesson plan has covered all SPS indicators. This indicates that the pre-service Biology teachers have made efforts to integrate SPS into the designed practical activities. The next aspect analyzed is the learning objectives. The learning design created has met the criteria for alignment with learning outcomes, the ABCD elements (Audience, Behavior, Condition, Degree), student characteristics, facts, concepts, and principles, as well as the description of the teaching materials. This indicates that the formulated learning objectives are directed and measurable. The aspect of learning media has also been well considered in the preparation of the lesson plans created by the students. The learning media included are in accordance with the learning objectives, learning materials, inquiry approach, use of local materials, and student characteristics. This shows that the pre-service teacher has considered the availability of resources and the learning context.

The next analysis was conducted on the aspect of the learning procedure. Although the lesson plan has explained the introductory, core, and closing activities, the elaboration of these activities is unclear in formulating the steps taken in inquiry-based learning. Additionally, the analysis results also show that in the preparation of lesson plans, pre-service biology teacher students lack detail in linking learning activities with the systematic structure of the material and the inquiry learning model. This indicates the need for strengthening the understanding and application of inquiry steps in lesson plan designs. Another aspect is the availability of the student worksheet. Based on the analysis results, the lesson plans created by pre-service Biology teachers have included students' worksheets that contain all SPS indicators, thereby supporting the effectiveness of inquiry-based learning. In addition, the assessment guide for the student's worksheet has also been well included, making the evaluation process easier and ensuring the achievement of learning objectives.

The next aspect to be analyzed is the completeness of the assessment. The learning design created is quite comprehensive, covering assessments for knowledge, skills, and attitudes in accordance with the learning objectives. Lastly, an analysis is conducted on the accuracy of the assessment (the alignment of the assessment with the learning outcomes). Based on the analysis results, the assessments included are accurate and align with the learning outcomes, thereby supporting the effective measurement of competency achievement. Overall, it can be concluded that pre-service Biology teachers have demonstrated good abilities in designing several aspects of inquiry-based practical learning, such as identity, learning outcomes, SPS, learning objectives, facilities and infrastructure, students' worksheets, assessment guidelines, and evaluation. However, there is a need to strengthen the learning procedure aspect, particularly in integrating inquiry steps more explicitly and structurally. The graph of the analysis results of the learning design created by the students is presented in Figure 1.

Identity Completeness

Based on Figure 1, in the aspect of Identity Completeness, students received quite low scores (77). Meanwhile, the score on the completeness of identity indicates that there are still deficiencies in writing the identity of the learning design, although in general, the important elements have been included. The low score on the completeness of the lesson plan identity (only "sufficient") indicates that pre-service teachers often neglect simple administrative data such as the name of the educational institution, subject, or time allocation. The analysis of lesson plans developed by pre-service biology teachers revealed that the completeness of identity information remains suboptimal. While essential elements such as learning objectives and materials are generally present, administrative details like the name of the educational institution, subject, and time

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allocation are often omitted. This indicates a need to enhance the attention of pre-service teachers to the administrative components of lesson planning.

Research by Sabilah et. al. (2022) underscores the importance of comprehensive identity information in lesson plans. Their study on teacher professional education coaching found that including complete identity details is crucial for producing high-quality lesson plans that align with curriculum standards and facilitate effective teaching practices. The coaching program emphasized the necessity of meticulous documentation, including administrative aspects, to ensure clarity and accountability in lesson implementation. Therefore, to improve the quality of lesson plans, it is imperative for teacher education programs to reinforce the significance of complete identity information. This includes training pre-service teachers to consistently include all necessary administrative details, thereby fostering professionalism and adherence to educational standards in their instructional planning.

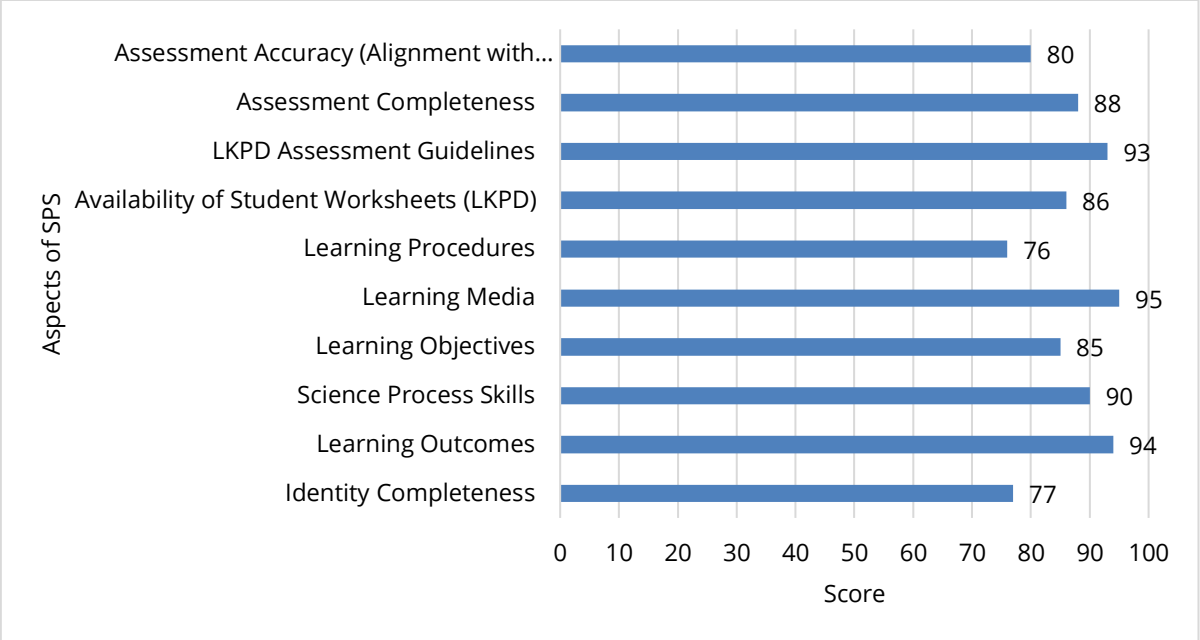

Figure 1. Lesson plan evaluation chart based on observed aspects

Learning Outcomes

The analysis of inquiry-based biology practicum lesson plans developed by pre-service biology teachers revealed a high proficiency in formulating learning outcomes, with an impressive score of 94. This indicates that the pre-service biology teachers possess a strong understanding of the curriculum and the competency demands that students must achieve. Their ability to align learning outcomes with the competencies and materials being taught reflects a commendable level of curriculum literacy. This finding is supported by a study conducted by Arsih et al. (2021), which investigated the effectiveness of the result of development of a problem-based learning model that integrates an ethnopedagogical approach Minangkabau culture (RANDAI) learning model, in enhancing pre-service biology teachers' critical thinking skills. The study emphasized the importance of well-formulated learning outcomes in lesson plans, noting that clear and competency-aligned objectives are crucial for guiding instructional strategies and assessments. Therefore, the high score in the learning outcomes aspect of the lesson plans suggests that pre-service biology teachers are well-prepared to design instructional activities that meet curriculum standards and foster essential competencies in students. This proficiency is a positive indicator of their readiness to implement effective inquiry-based learning experiences in their future teaching practices.

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Science Process Skills

In the aspects of Science Process Skills (SPS) and students received quite high scores, namely 90, indicating that the pre-service teachers have made efforts to integrate SPS into their learning activity. This outcome reflects the deliberate and thoughtful efforts made by these pre-service educators to incorporate SPS into their teaching designs, indicating a solid grasp of the foundational elements of scientific inquiry. This result is consistent with the findings of Wola et. al (2023), who investigated the application of SPS among pre-service science teachers during laboratory practicum sessions. Their study revealed that hands-on learning experiences significantly contribute to the development of core scientific skills such as observing, hypothesizing, experimenting, and data interpretation. The researchers highlighted that such practical engagements are essential for cultivating the competencies needed to support inquiry-driven teaching environments. Consequently, the high performance in the SPS component of the lesson plans suggests that pre-service biology teachers possess the necessary skills to create instructional activities that nurture analytical thinking and scientific exploration. This level of preparedness serves as a promising indicator of their potential to enhance students' scientific literacy and inquiry capabilities in their future classrooms.

Learning objectives

The analysis of learning objectives within the lesson plans created by pre-service biology teachers yielded an average score of 85. This outcome illustrates their competence in composing objectives that follow the ABCD (Audience, Behavior, Condition, Degree) framework while also considering the diverse characteristics of learners. The ability to formulate such objectives reflects not only pedagogical understanding but also an awareness of instructional clarity and relevance. These results resonate with the work of Jiménez (2025), who explored the design practices of pre-service teachers and identified that while many could formulate objectives aligned with Bloom's Taxonomy, some inconsistencies remained in applying the ABCD format systematically. Nevertheless, the presence of structured objectives was seen as a foundational element in crafting purposeful lesson plans. In a related study, Lumbreras and Rupley (2020) found that integrating the Understanding by Design (UbD) model into teacher preparation programs significantly enhanced pre-service teachers' skills in establishing well-defined learning goals and aligning them with appropriate assessments. Their findings underscore the value of clearly articulated objectives as a cornerstone of effective instructional design. Taken together, the strong performance of pre-service biology teachers in this aspect suggests a solid level of preparedness in constructing lesson plans that foster inquiry and support meaningful learning outcomes. It also highlights their potential to implement coherent and goal-oriented instruction in future educational settings.

Learning Media

High scores were also obtained in the aspects of learning media (95). This indicates that pre-service biology teacher students have considered the availability of resources. This aspect is very important because adequate facilities greatly support the successful implementation of inquiry-based learning in the classroom. The very good scores on facilities/infrastructure and laboratory equipment reflect the pre-service teachers' mastery of practical equipment. These findings are in line with the research by Muthmainnah et al. (2023), which shows that training in the use of laboratory equipment and the introduction of simple biology practicals can enhance the understanding and skills of biology teachers and students in operating laboratory equipment. Additionally, research by Mardiyah (2023) shows that experienced biology teachers are capable of designing and implementing applied microbiology practicals using local materials, demonstrating competence in the mastery of laboratory tools and materials. The readiness of biology laboratories to support practical activities is also an important factor, as shown by research at SMA Negeri Kabupaten Brebes, which indicates that the biology laboratories are ready to support practical activities with an average readiness level of 73.29% (Indriastuti et al., 2017). Thus, the

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mastery of pre-service teachers over practical equipment becomes an important indicator of their readiness to design and conduct inquiry-based practicals effectively.

Availability of Student's Worksheet

The analysis of lesson plans developed by pre-service biology teachers revealed that the availability of inquiry-based student worksheets remains inconsistent. Many students have not yet optimally integrated the students' worksheet as an essential component of inquiry-based learning strategies. This highlights the need to strengthen students' understanding and skills in designing the students' worksheet that effectively supports scientific inquiry processes. Firdaus and Wilujeng (2018) emphasized the importance of developing guided inquiry-based student worksheets to enhance students' critical thinking skills and learning outcomes. They designed the students' worksheet aimed at encouraging students to formulate questions, develop hypotheses, and conduct experiments—core elements of the inquiry approach. Their study demonstrated that the use of guided inquiry-based the students' worksheets can significantly improve students' critical thinking skills. In addition, a study by Estitika et. al. (2022) developed a guided inquiry-based the students on the topic of Fungi for grade X senior high school students. Their findings indicated that the students' worksheet designed using guided inquiry approaches can enhance students' conceptual understanding and science process skills. This evidence underscores that well-designed students' worksheets can serve as effective tools to support inquiry-based learning. These findings suggest that integrating inquiry-based learning into the students' worksheets into lesson plans is crucial for fostering students' critical thinking skills and conceptual understanding. Therefore, it is necessary to enhance pre-service teachers' competencies in designing effective students' worksheets that align with the principles of inquiry-based learning.

Worksheet Assessment Guidelines

The high score of 93 in the worksheet assessment guidelines indicates that pre-service biology teachers have demonstrated a strong consideration in preparing adequate assessment instruments. This suggests that they are capable of designing assessment tools that align with learning objectives and effectively measure student understanding. Supporting this finding, a study by Suryani et. al. (2022) emphasizes the importance of developing assessment competencies among biology teachers in designing learning tools based on pedagogical and professional competencies. Their research highlights that well-structured assessment instruments are crucial for evaluating student learning outcomes and ensuring the effectiveness of instructional strategies. The study found that biology teachers who engaged in targeted assessment training were better equipped to create comprehensive evaluation tools that align with curriculum standards and learning goals. Therefore, the ability of pre-service biology teachers to develop thorough assessment guidelines within their worksheets reflects a positive trend towards enhancing assessment literacy, which is essential for effective teaching and learning processes.

Assessment Completeness

Assessment completeness (88) reflects the comprehensive coverage of assessment components. Pre-service teachers demonstrated the ability to develop well-structured and comprehensive evaluation instruments. Another advantage found in this study is the readiness of basic assessment tools, such as Student Worksheets and the assessment guidelines, which show that pre-service teachers have included rubrics and assessment instruments. These findings are in line with Ningsih's (2018) research, which shows that pre-service biology teachers are capable of developing assessment tools in the good category, particularly in the aspects of attitude, knowledge, and skills assessment. This ability reflects the pre-service teachers' awareness of the importance of aligning assessment instruments with learning objectives. Additionally, the study by Aprilia et al. (2020) developed a guided inquiry-based practicum guide that is valid and practical, and is equipped with an assessment rubric that aligns with learning indicators. This shows that

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the integration of systematic assessment tools in practical activities can enhance the quality of assessments conducted by pre-service teachers. Thus, the readiness of assessment tools possessed by pre-service biology teachers not only reflects their understanding of the curriculum but also demonstrates their ability to design effective assessments that align with learning objectives.

Learning Procedures

However, relatively lower scores were obtained in the aspects of learning procedures (76). The score on the learning procedures indicates that pre-service teachers still need to improve their ability to detail inquiry learning steps systematically and structurally. The elaboration of learning activities, especially in the core and closing stages, needs to be clarified and explicitly linked to the inquiry stages. The weakness in the lesson plans created by the students is also evident in the writing of the learning procedures (score 76), specifically the inquiry learning steps that are lacking in detail. The results of this study indicate that the weaknesses in the lesson plans created by the students are evident in the writing of the learning procedures, with an average score of 76. This reflects that the inquiry learning steps that were designed are still lacking in detail and do not systematically depict the stages of inquiry. These findings are consistent with the research by Rosnita et al. (2016), which revealed that pre-service teacher students have low inquiry skills, particularly in designing learning steps that align with the inquiry syntax. These deficiencies include aspects of planning investigation activities, formulating questions, and data analysis, which are important components in inquiry-based learning. Therefore, efforts are needed to enhance students' competencies in designing more structured and in-depth inquiry-based learning procedures.

Assessment Accuracy

Another aspect analyzed in the learning design is the accuracy of the assessment, with a score of 80, which indicates that the alignment between the assessment instruments and the learning objectives is not yet optimal. These findings align with the research by Qurtubi et al. (2024), which emphasizes the importance of the alignment between assessment instruments and learning objectives to enhance the effectiveness of learning evaluations. This gap indicates that pre-service teachers need guidance to align learning objectives with assessment tasks, so that evaluations truly reflect competency achievements. This observation is consistent with the findings of Akbar and Sulastini (2023), who conducted a content analysis on the alignment of assessment tasks with intended learning outcomes in higher education courses. Their study revealed that although some assessment tasks were well-aligned with learning objectives, others lacked congruence, particularly in assessing higher-order thinking skills. This underscores the necessity for educators to ensure that assessment tasks are thoughtfully designed to reflect and measure the specific competencies outlined in the learning objectives. Furthermore, the research by Jaelani and Umam (2021) emphasizes the importance of integrating authentic assessment practices in teacher education programs. Their study demonstrated that the use of authentic materials and assessments not only enhances the relevance of the learning experience but also improves pre-service teachers' ability to design assessments that are aligned with real-world applications and learning objectives. Therefore, there is a need to enhance students' competencies in designing assessment instruments that align with learning objectives, particularly in the context of inquiry-based learning.

The difficulty of pre-service biology teachers in designing adequate practical procedures and providing appropriate support during the inquiry process remains a challenge in the learning process. These findings are in line with Yunus's (2023) research, which revealed that the critical thinking skills of pre-service biology teachers vary greatly, with most falling into the moderate to high category, but there are still some in the low category. Additionally, Mahdiannur et. al. (2021) found that the inquiry process skills of pre-service science teachers are influenced by gender and

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duration of study. Female students tend to excel in formulating problems and designing experiments, while male students show superiority in making predictions and applying statistical methods. These findings are supported by Wulandari's (2021) study, which shows that the development of inquiry-based practical guides in the General Biology course significantly enhances students' practical skills. Therefore, more intensive training and mentoring are necessary to enhance the competence of pre-service teachers in designing and implementing inquiry-based practical learning effectively.

In general, the results of this study indicate that the majority of pre-service teachers fall into the category of having fairly good or very good lesson planning competencies. Ita et. al. (2021) reported that around 69.7% of pre-service biology teacher students have "very good" competence in designing lesson plans. The findings are in line with most aspects of the lesson plan in this study, which received high scores (good to very good). However, the small percentage of the "poor" category, which is 3.03% (Ita et. al., 2021), is still relevant to the weak aspects of this study, namely identity, procedures, and assessment accuracy. Thus, a similar pattern of strengths and weaknesses has been previously reported among pre-service biology teachers.

As for the assessment aspect, research by Sari and Agustina (2021) shows that many pre-service teachers still have difficulty in developing assessment instruments that align with learning objectives and indicators in the syllabus. This underscores the need to enhance the competence of pre-service teachers in designing valid and reliable assessments, considering that the alignment of assessments with learning objectives is one of the main pedagogical competencies (Permendikbud No. 22, 2016).

Designing inquiry-based learning indeed demands complex skills. Koberstein-Schwarz & Meisert (2024) emphasize that "lesson planning is a core task for pre-service teachers and a significant challenge due to its complexity." Furthermore, various international studies show that the inquiry method often poses difficulties for both novice and experienced teachers; preservice teachers struggle to guide students in inquiry-based learning, which requires a deep understanding of the nature of science. This is reflected in the research data, which shows that although many aspects of planning are mastered, low achievement in learning procedures and assessments indicates that pre-service teachers still need further deepening, for example, in designing structured inquiry steps and truly integrated assessment instruments. Improvement strategies may include learning simulations, microteaching, or providing learning design models as guides. As a note, the quality of inquiry planning correlates with pedagogical content knowledge (PCK); improving this ability will enhance the effectiveness of laboratory-based Biology teaching.

CONCLUSION

Based on the research results, the inquiry-based biology practical learning design prepared by pre-service biology teacher students demonstrates good mastery in several important aspects, such as the completeness of identity, learning outcomes, science process skills, and learning objectives. This is reflected in the integration of important elements in the design, alignment with inquiry principles, and the inclusion of the students' worksheet that covers all SPS indicators. However, there are still weaknesses in the learning procedures, especially in detailing the inquiry steps explicitly and systematically. Additionally, although the assessments developed are accurate and comprehensive, strengthening the understanding of integrating inquiry-based learning components is still necessary. These findings indicate that pre-service Biology teachers are on the right track in developing inquiry-based learning designs, but further development is needed, particularly in the detailed procedural aspects and implementation of the inquiry stages.

Overall, the research data shows that pre-service Biology teachers have adequate inquiry-based practical learning design skills in the most important aspects, especially in formulating learning objectives, selecting facilities/infrastructure, and preparing student worksheets and assessment guidelines. However, there are weaknesses in the aspects of lesson plan procedures

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and administration, as well as assessment alignment, which require special attention. These findings are consistent with previous research in Indonesia that highlights similar patterns of strengths and weaknesses. Therefore, the refinement of learning that emphasizes the practice of designing inquiry learning steps and integrating assessments with objectives needs to be strengthened to enhance the professionalism of pre-service Biology teachers.

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