

# Pre-service biology teachers' knowledge of the 21<sup>st</sup>-century skills and its associated instructional models: The Indonesian context

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**Abstract:** Integrating the 21<sup>st</sup>-century skills into Indonesia's education system is crucial for equipping students to face future challenges. This study investigates the knowledge of pre-service biology teachers in Indonesia regarding the 21<sup>st</sup> -century skills and their understanding of instructional models that support skill development. Conducted from March to September 2024, the research employed a cross-sectional survey design with a total sampling technique, involving 78 students from a Biology Education program at a public Islamic university in North Sumatra, all of whom had completed a course on biology learning strategies. Data were gathered using questionnaires and analyzed quantitatively to determine key trends. The findings indicate that although most students recognize the significance of the 21<sup>st</sup> -century skills in biology education, their understanding is limited. Only a small number could identify all essential skills, with creative thinking being the most recognized. Students were well-acquainted with project-based learning as a model for developing these skills but had limited knowledge of the structure and application of other instructional models, such as discovery and inquiry learning. These findings emphasize the need for curriculum improvement to deepen students' comprehension of various instructional models and the integration of diverse information sources, enabling more effective integration of the 21<sup>st</sup> -century skills into biology education.

**Keywords:** instructional models; pre-service biology teachers; the 21<sup>st</sup>-century skills

## Introduction

Education is a critical foundation for developing a future generation that is both excellent and adaptable to the ever-changing demands of society and future professions (Coskun, 2022). As technology advances rapidly and societal dynamics shift, the role of teachers is evolving beyond traditional expectations (Benade, 2017; Crosswell, 2017). Pre-service biology teachers, in particular, face increasing complexity as they enter the era of the 21<sup>st</sup>-century skills. The 21<sup>st</sup>-century competencies, essential for navigating a rapidly evolving world shaped by technological advancements, emphasize both new and traditional skills, equipping individuals for modern thinking, working, and living, as outlined in the ATC21S framework (Binkley et al., 2012; Caena & Redecker, 2019). Therefore, these educators must be equipped with strong pedagogical competencies, including the ability to incorporate innovative teaching strategies that meet the demands of modern education.

Pedagogical competence extends beyond classroom instruction to encompass the ability to design and implement innovative learning strategies that align with the evolving demands of the 21<sup>st</sup>-century skills. The development of the 21<sup>st</sup> -century skills is crucial for students at all educational levels (Barus, 2024). These skills are essential for adapting to rapidly changing times and preparing students for future societal demands (Barus, 2024). For prospective teachers, critical thinking and collaboration

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skills are fundamental, enabling them to improve the quality of teaching and learning processes. The importance of developing these skills is widely recognized by students and educators alike (Sudrajat et al., 2020). However, there is a growing need to incorporate the 21<sup>st</sup>-century skills development in classrooms, as traditional education systems focused on knowledge accumulation are becoming less relevant. Innovative approaches, such as personalized learning and integrated methods, are necessary to address the challenges posed by technological advancements and the changing job market (Lazorenko & Krasnenko, 2019).

To address these issues, Initial teacher education plays a crucial role in preparing future educators for the challenges of modern education. As the field continues to evolve, it is crucial for teachers to develop adaptability (Ganziera et al., 2019; Ramdani et al., 2022) and address the diverse needs of their students (Toraeva, 2022). Teacher preparation programs should offer opportunities for teacher candidates to learn, develop, and practice the 21<sup>st</sup>-century skills like creativity, critical thinking, communication, and collaboration (Cretu, 2017). Equipping teachers with the ability to implement innovative learning models is critical, as it enables them to develop students' 21<sup>st</sup>-century competencies, including critical and creative thinking skills. These higher-order thinking skills must be intentionally cultivated through the learning process, which poses challenges for teachers today (Niza & Suyanto, 2023; Yen & Teo, 2019; Alfriyani et al., 2021).

Despite the increasing emphasis on the 21<sup>st</sup>-century skills in education, significant gaps remain in the preparedness of pre-service biology teachers to effectively integrate these skills into their teaching practices. Although pedagogical training is provided, the reality in the field shows that not all pre-service teachers possess sufficient pedagogical skills. This aligns with Jayanti's (2020) research, which found that biology pre-service teachers lacked proficiency in designing lesson plans, particularly in aligning activities with the syntax of instructional models. Many students still rely heavily on rote learning and have limited exposure to innovative teaching strategies.

Further supporting this, Jayanti's (2022) research highlights that students continue to struggle in understanding the variety of instructional models. This difficulty may stem from insufficient training in the application of modern instructional models, as well as a traditional focus on memorization over critical thinking and creativity. Consequently, pre-service teachers often face challenges in planning and executing lessons that effectively foster the 21<sup>st</sup>-century skills such as collaboration, creativity, and critical thinking. This misalignment suggests that current pedagogical training may not be adequately addressing the needs of future teachers to fully embrace the 21<sup>st</sup>-century teaching practices.

The central problem of this research is the potential misalignment between the educational expectations placed on pre-service teachers in Indonesia and their actual knowledge and preparedness to integrate the 21<sup>st</sup>-century skills into their teaching practices. Despite the increasing emphasis on equipping future educators with these essential skills, many pre-service teachers still lack a comprehensive understanding of the instructional models that effectively support the development of the 21<sup>st</sup>-century competencies. Therefore, it is necessary to examine pre-service teachers' knowledge of the 21<sup>st</sup>-century skills and the relevant instructional models before implementing targeted interventions to address the challenges identified in previous discussions. This approach will ensure that the solutions provided are tailored to the actual needs and gaps in the teachers' pedagogical preparation.

Nevertheless, research on the knowledge of pre-service biology teachers regarding the 21<sup>st</sup>-century skills and associated instructional models remains relatively limited. Most previous studies have focused more on the application of the 21<sup>st</sup>-century skills in general educational contexts, rather than specifically addressing pre-service biology teachers. For instance, the study Haviz et al. (2020) assessed pre-service teachers' perceptions of the 21<sup>st</sup>-century skills in Indonesia in general but did not explore how pre-service biology teachers understand and integrate these skills into biology teaching. Moreover, research that specifically analyzes the ability of pre-service teachers to understand innovative learning models such as project-based learning, discovery learning, and inquiry-based learning, and how these models can be used to develop the 21<sup>st</sup>-century skills, is still scarce.

Existing studies, such as those conducted by Jayanti (2020, 2022), highlight gaps in the pedagogical skills of pre-service biology teachers, particularly in designing and implementing lesson plans that align with the syntax of instructional models. However, research explicitly connecting their understanding of instructional models with their ability to integrate the 21<sup>st</sup>-century skills are still lacking. Therefore, further research is needed to fill this gap and provide a deeper understanding of how pre-service biology teachers can be better prepared to meet the challenges of the 21<sup>st</sup>-century education.

Thus, the aim of this study is to assess the level of knowledge that pre-service teachers in Indonesia possess regarding the 21<sup>st</sup>-century skills and to identify the instructional models they are familiar with and utilize to integrate these skills into their teaching practices. By understanding the current proficiency of pre-service teachers in these critical areas, the research will highlight gaps in their preparation and inform necessary curriculum enhancements. The implications of this research are significant, as the findings will provide insights that can guide the development of targeted training programs, ensuring that future educators are equipped with the essential competencies needed to

foster the 21<sup>st</sup>-century skills among their students, ultimately contributing to a more effective and responsive education system in the context of the 21<sup>st</sup>-century challenges.

## Method

This study employed a cross-sectional survey design (Creswell, 2012) to examine pre-service biology teachers' knowledge of the 21<sup>st</sup>-century skills and their associated instructional models within the Indonesian context. The cross-sectional survey design was particularly suitable for this study because it offered an efficient way to gather broad data within a limited timeframe, providing an overall picture of pre-service biology teachers' knowledge without the need for long-term follow-up.

The study was conducted from March to September 2024 at one of State Islamic Higher Education Institutions in Medan, North Sumatra. The research involved 78 students from the Biology Education program at an Islamic public university in North Sumatra, all of whom had completed a biology learning strategies course, making them a suitable sample to assess their knowledge of the 21<sup>st</sup>-century skills. A total sampling technique was employed to include all students who met the criteria of having completed the relevant course.

Data were gathered through an open questionnaire distributed directly to the respondents. The questionnaire was adapted from Sari (2019) and included ten items designed to assess two aspects: the understanding of the 21<sup>st</sup>-century skills and integration of the 21<sup>st</sup>-century skills in classroom. Aspect 'understanding of the 21<sup>st</sup>-century skills' consisted of three indicators namely 1) knowing the 21<sup>st</sup>-century skills (2 questions); 2) understanding the concept of the 21<sup>st</sup>-century skills (1 question); dan 3) awareness of the importance of the 21<sup>st</sup>-century skills (1 question). Meanwhile, aspect integration of the 21<sup>st</sup>-century skills in learning' comprises of one indicator namely understanding the integration of the 21<sup>st</sup>-century learning and innovation skills in instructional models (7 questions).

Following data collection, the research data analysis process adhered to the procedures outlined by Hadeli (2006). The research data analysis began with the Editing stage. Here, the researcher examined the completeness of the collected questionnaire data to determine whether all responses could be fully utilized or if only those meeting specific criteria would be analyzed. This was followed by the Scoring phase, where qualitative responses from students about their understanding of the learning model's syntax were assessed. A five-point scale was used, ranging from 1 (Very Unaware), indicating no knowledge of the syntax, to 5 (Very Knowledgeable), indicating comprehensive knowledge of all syntax aspects. Intermediate scores reflected partial understanding, with 2 (Unaware) for familiarity with one aspect, 3 (Fairly Knowledgeable) for awareness of two or three aspects, and 4 (Knowledgeable) for understanding three or four aspects.

The next step, Tabulating, involved systematically organizing the data into tables and diagrams to facilitate analysis. This was followed by Displaying, where the findings were presented in a narrative format to aid readers' understanding. Finally, in the Conclusion Drawing and Verification stage, the researcher interpreted the results within the context of existing theoretical frameworks, formulating insights and verifying their alignment with established knowledge.

## Results and Discussion

The analysis of pre-service biology teachers' knowledge of the 21<sup>st</sup>-century skills and the instructional models supporting these skills was based on survey responses from 78 students enrolled in the Biology Education program, all of whom had completed the 'Biology Learning Strategies' course. The following describes the analysis results based on the aspects and indicators of the instrument used to examine pre-service biology teachers' knowledge of the 21<sup>st</sup>-century skills and their associated instructional models within the Indonesian context. The analysis focused on key competencies of the 21<sup>st</sup>-century skills, alongside the instructional models designed to foster these skills.

### The comprehension of preservice biology teachers' knowledge regarding the 21<sup>st</sup>-century skills

In assessing the current state of pedagogical readiness, it is essential to examine preservice biology teachers' understanding of the 21<sup>st</sup>-century skills. These skills, crucial for preparing students to navigate modern challenges, include critical thinking, creativity, collaboration, and communication. The analysis reveals that 84% of the students are either familiar with or have been exposed to these competencies, while 16% report no prior knowledge, as illustrated in Figure 1.

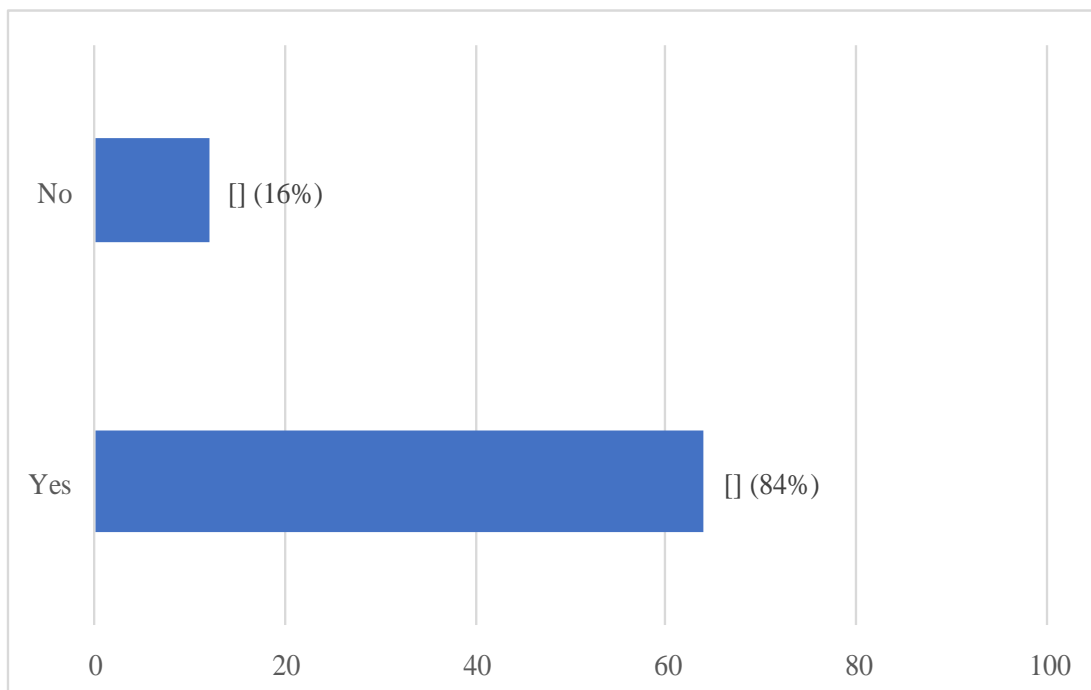


Figure 1. The proportion of students familiar with or having exposure to the 21<sup>st</sup>-century skills

The findings from the analysis underscore both progress and gaps in preservice biology teachers' preparedness to integrate the 21<sup>st</sup>-century skills into their teaching practice. With 84% of students indicating familiarity or exposure to these competencies, there is a promising foundation for building the necessary pedagogical approaches. However, the 16% of students who report no prior knowledge of these skills signals a significant challenge in ensuring consistent training and awareness. This data highlights the need for targeted instructional strategies to bridge the knowledge gap and ensure comprehensive skill development in future educators.

This disparity suggests that while many preservice teachers are on the path to developing the critical, creative, and collaborative skills required for modern education, there is still a pressing need for targeted instructional strategies that address the knowledge gaps. By fostering a more uniform understanding of these essential competencies, teacher education programs can better equip all future educators to implement innovative, student-centered approaches in the classroom.

To gain insights into how preservice biology teachers acquire knowledge about the 21<sup>st</sup>-century skills, it is important to explore the various sources of information they rely on. Understanding where students turn for information can highlight the accessibility and influence of different learning platforms and help identify areas where more structured, formal instruction might be needed. Additionally, examining these sources can provide valuable context for enhancing teacher education programs by ensuring that reliable and comprehensive materials are readily available to support the development of critical competencies. Among the respondents, 80% identified the internet as their primary source of information on the 21<sup>st</sup>-century skills, followed by 59% who cited lectures, and 39% who referenced scientific journal articles. These findings are illustrated in [Figure 2](#).

These results indicate that, although the majority of students possess a basic understanding of the 21<sup>st</sup>-century skills, there is a significant reliance on digital sources and lectures for acquiring this information. [Saavedra and Opfer's \(2019\)](#) research underscore the importance of integrating the 21<sup>st</sup>-century skills into the curriculum to ensure students are well-prepared to face modern challenges. Similarly, [Voogt and Roblin \(2019\)](#) highlight that effective instructional models must support the development of the 21<sup>st</sup>-century competencies, such as critical thinking and collaboration.

Furthermore, [Figure 3](#) illustrates the percentage of students who identified the components of the 21<sup>st</sup>-century skills.

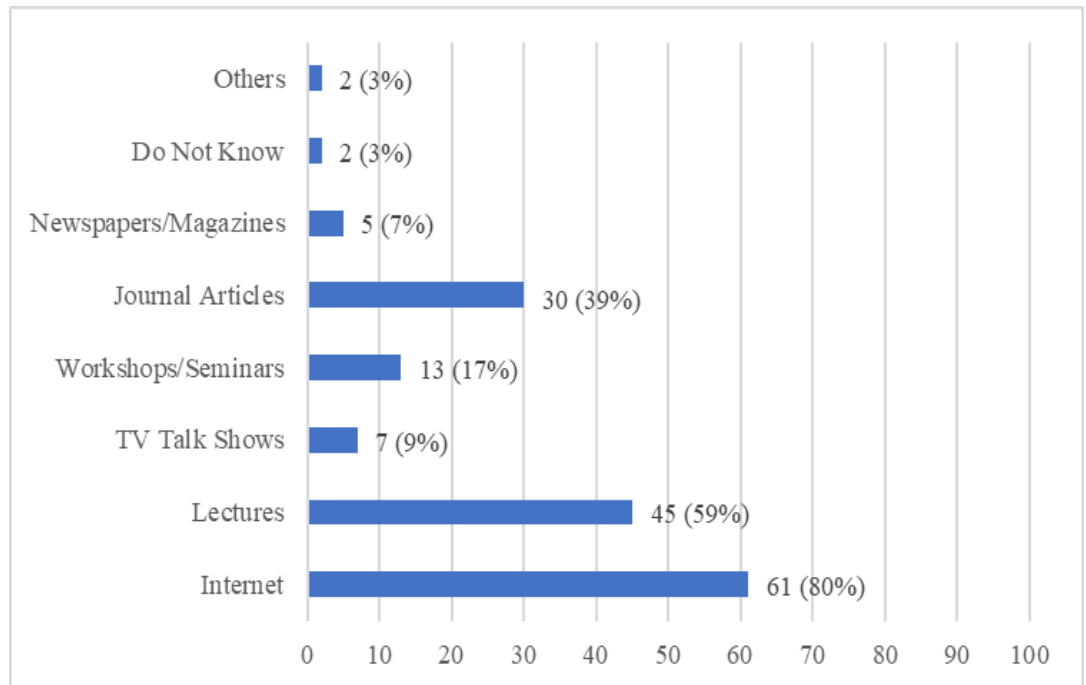


Figure 2. The distribution of student responses concerning the sources of their knowledge on the 21<sup>st</sup> - century skills

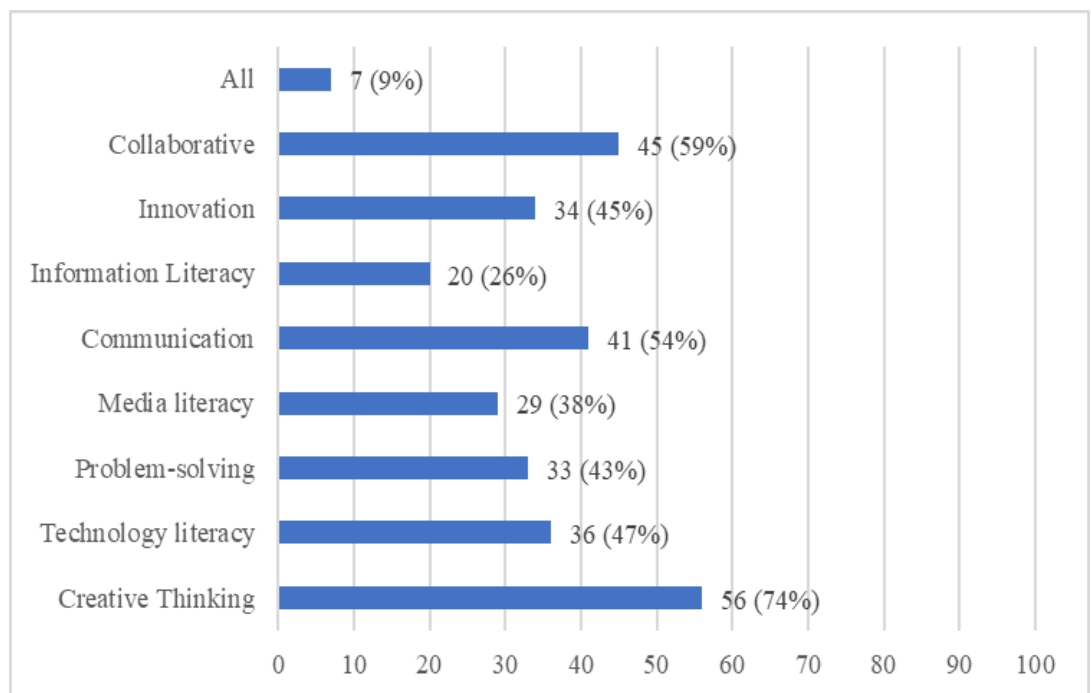


Figure 3. The proportion of students who recognized the elements of the 21<sup>st</sup>-century skills

Out of the eight 21<sup>st</sup>-century skills provided, which include collaborative skills, innovation, information literacy, communication, media literacy, problem-solving, technology literacy, and creative thinking, only 9% of students identified all of these as the 21<sup>st</sup> -century skills. A total of 74% of students recognized creative thinking as a 21<sup>st</sup>-century skill, followed by collaborative skills, communication, technology literacy, problem-solving, innovation, media literacy, and information literacy. When asked about the urgency of facilitating the development of the 21<sup>st</sup>-century skills in biology education, 99% of students indicated that such facilitation is necessary.

The conclusion drawn from the analysis of students' knowledge regarding the 21<sup>st</sup>-century skills indicates that, although the majority of students (99%) recognize the importance of facilitating the development of these skills in biology education, their understanding of the specific types of skills remains limited. Of the eight 21<sup>st</sup>-century skills presented—comprising collaborative skills, innovation, information literacy, communication, media literacy, problem-solving, technological literacy, and creative thinking—only 9% of students were able to identify all of these skills as part of the 21<sup>st</sup>-century skill set. Most students identified creative thinking as the most relevant skill, followed by collaborative skills, communication, technological literacy, and problem-solving.

These findings reveal a gap in students' understanding of the comprehensive scope of the 21<sup>st</sup> - century skills and underscore the need to strengthen the integration and comprehension of these skills within the biology curriculum. Research by [P21 \(2019\)](#) indicates that a better understanding of the 21<sup>st</sup> -century skills can enrich the learning process. Additionally, the study by [Voogt and Roblin \(2019\)](#) emphasizes the importance of incorporating various 21<sup>st</sup>-century skills into the curriculum to prepare students for global challenges. Furthermore, research by [Huang et al \(2020\)](#) highlights that creative and collaborative thinking skills are often primary focuses in the development of skills-based 21<sup>st</sup>-century curricula.

### The comprehension of preservice biology teachers regarding the integration of the 21st-century skills within classroom instruction

Subsequently, to evaluate students' understanding of instructional models that facilitate the development of the 21<sup>st</sup>-century skills, they were initially presented with questions concerning various approaches for cultivating these skills as presented in [Figure 4](#). Of the respondents, 71% identified the scientific approach, while 55% selected a student-centered approach. A portion of students also favored a teacher-centered approach. Furthermore, 1% indicated a problem-based approach, and another 1% expressed uncertainty.

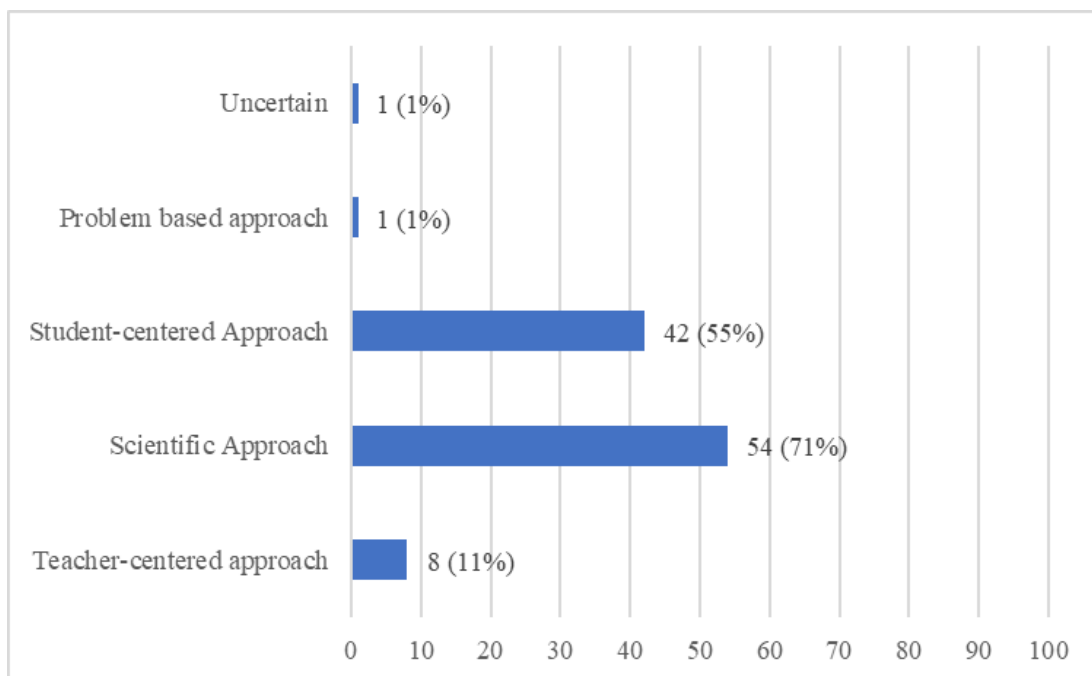


Figure 4. The proportion of student responses concerning approaches to fostering the 21st-century skills

These findings indicate that students tend to recognize the scientific and student-centered approaches as relevant strategies for supporting the 21<sup>st</sup>-century skills, although their understanding of the problem-based approach remains quite limited. Research by [Bell \(2010\)](#) suggests that the scientific approach can enhance the understanding and application of the 21<sup>st</sup>-century skills through research-based learning. Furthermore, [Hattie \(2019\)](#) underscores the significance of the student-centered approach in developing the 21<sup>st</sup>-century skills through active engagement and personalized learning. In addition, students were also provided with options related to instructional models that support the 21<sup>st</sup> -century skills, as illustrated in [Figure 5](#).

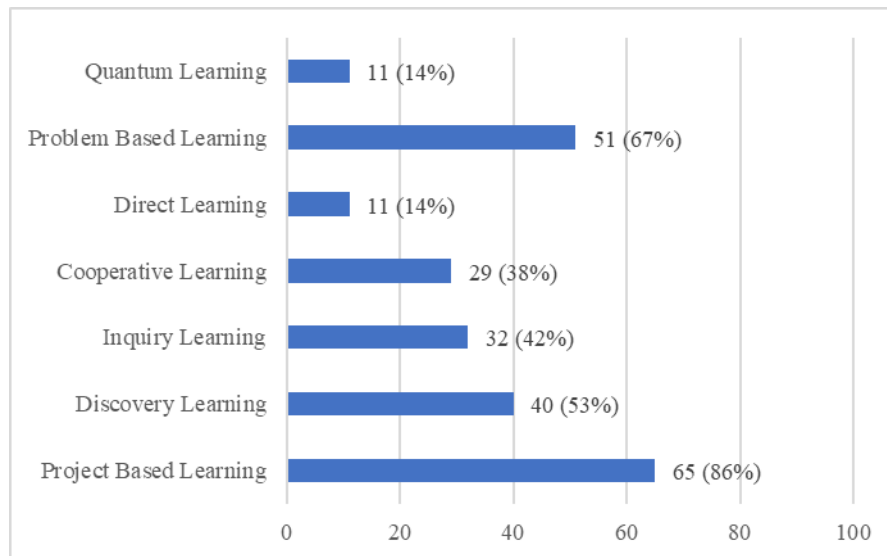


Figure 5. The distribution of student responses concerning instructional models to cultivating 21st-century skills

According to [Figure 5](#), 86% of students chose the project-based learning model, followed by problem-based learning, discovery learning, inquiry learning, and cooperative learning, each garnering 14%. These findings suggest that while students possess a strong understanding of the project-based learning model, their knowledge of the syntax and implementation of other models that foster the 21<sup>st</sup>-century skills still require improvement. Research by [Thomas \(2021\)](#) indicates that project-based learning effectively cultivates critical and collaborative skills. [Hattie \(2021\)](#) highlights the significance of student-centered learning models, such as inquiry learning, in promoting the 21<sup>st</sup>-century skills. Moreover, when prompted about their understanding of the syntax for each instructional model, students provided varied responses, as depicted in [Figure 6](#).

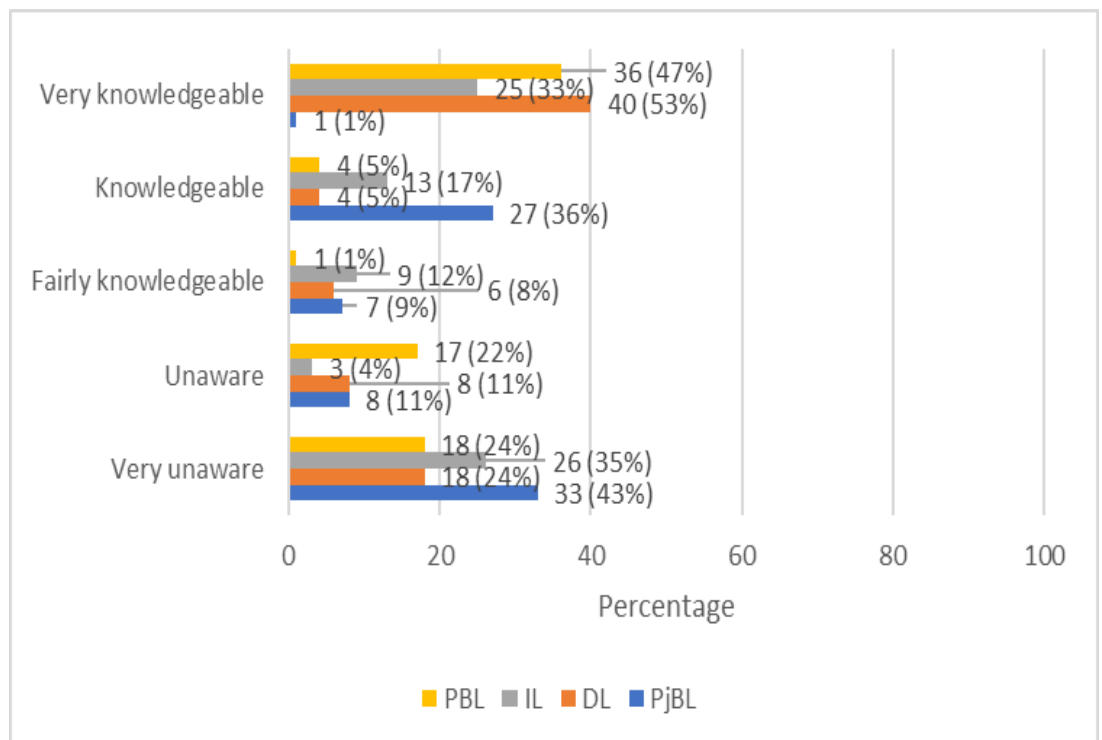


Figure 6. The percentage of students demonstrating a thorough understanding of the syntax for each instructional model

Overall, Discovery Learning (DL) appears to be the most widely recognized and understood instructional model among participants, as evidenced by the significantly higher number of respondents who consider themselves highly knowledgeable compared to other methods. In contrast, Project-Based Learning (PjBL) and Inquiry Learning (IL) exhibit moderate levels of understanding, although there remains a notable gap in deep comprehension. Problem-Based Learning (PBL) demonstrates the lowest level of awareness among participants, despite a few respondents displaying a solid understanding of the method.

This trend suggests that Discovery Learning (DL) has gained significant traction due to its alignment with contemporary educational practices that prioritize active, learner-centered approaches. This instructional model allows students to engage in exploration and problem-solving, fostering deeper cognitive engagement compared to more traditional methods.

On the other hand, the moderate awareness of Project-Based Learning (PjBL) and Inquiry Learning (IL) indicates that while these approaches are somewhat familiar, there is still a need for more comprehensive integration into educational practices to bridge the gap between surface-level familiarity and deep understanding. This is reinforced by [Connolly \(2022\)](#), which found that some pre-service teachers appeared to have difficulties in applying IL and PjBL ([Martinez, 2022](#)) in the classroom whereas they have heard about them. Moreover, it is necessary that pre-service teachers learn about the inquiry processes as well as how to use IL as an instructional strategy ([Hofer & Lembens, 2019](#); [Preston et al., 2015](#)).

This deeper understanding is essential for educators to effectively implement these methods, as it will enable them to design meaningful learning experiences that promote critical thinking and collaboration among students. Furthermore, professional development opportunities focusing on these pedagogical strategies can empower teachers to utilize PjBL and IL ([Barron & Darling-Hammond, 2010](#)) more effectively, ultimately enhancing student engagement and achievement. As institutions begin to prioritize these innovative teaching practices, fostering a culture of continuous learning and adaptation will be crucial in ensuring that educators are equipped to meet the diverse needs of their students in a rapidly changing world.

[Martinez \(2022\)](#) revealed that using PjBL as an integrated teaching and learning strategy in the preparation of teachers can develop the self-efficacy required to support the curricular demands necessary to address the learning needs of students for the 21<sup>st</sup>-century. Through academically demanding projects, students gain in-depth subject knowledge while also developing the 21<sup>st</sup>-century success skills, such as critical thinking, evaluating the accuracy of information, collaborate with a variety of colleagues, and creative problem-solving ([Boss & Krauss, 2014](#)).

This challenge is also reflected in the relatively low awareness of Problem-Based Learning (PBL), which despite its efficacy in promoting critical thinking and complex problem-solving ([Hmelo-Silver, 2004](#)), seems to be underutilized, pointing to a need for more focused professional development and pedagogical training to enhance its application in educational settings.

## Conclusion

In conclusion, the analysis of pre-service biology teachers' knowledge of the 21<sup>st</sup>-century skills and the instructional models supporting these skills reveals a promising, yet uneven understanding. While a large proportion of participants recognize the importance of integrating the 21<sup>st</sup>-century skills into education, gaps in specific knowledge remain, particularly concerning lesser-known models such as PjBL and Inquiry Learning. Discovery Learning emerges as the most widely understood instructional model, benefiting from its alignment with modern, learner-centered educational approaches that promote active problem-solving and engagement. In contrast, Project-Based Learning and Inquiry Learning demonstrate moderate levels of awareness, suggesting the need for deeper exploration and integration within the curriculum. The limited awareness of PBL, despite its effectiveness in fostering critical thinking, highlights the necessity for enhanced professional development and pedagogical strategies. These findings suggest that while progress has been made, further efforts are required to ensure that pre-service biology teachers are fully equipped with the comprehensive knowledge and instructional tools necessary to develop the 21<sup>st</sup>-century competencies in their future students.

To address these findings, several recommendations are proposed. First, there is a clear necessity for curriculum enhancement to include a broader range of instructional models and approaches that facilitate the development of the 21<sup>st</sup>-century skills. By strengthening students' knowledge of these diverse models, they will be better prepared to face future challenges and improve their educational outcomes. Furthermore, the reliance on digital sources and lectures for information on the 21<sup>st</sup>-century skills suggest the need to incorporate a wider array of information sources, such as academic journals, practical case studies and the development of comprehensive teaching resources focused on the concept of the 21<sup>st</sup>-century skills, assessment methods, and supportive instructional models. By



implementing these strategies, educational institutions can better prepare students for the demands of the modern world while enhancing their overall learning experience.

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## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

## Author Contributions

**U. N. A. D. Jayanti:** methodology; **U. N. A. D. Jayanti;** **M. N. Adlini** and **Y. N. R. Wiryawan:** analysis; **U. N. A. D. Jayanti:** writing original draft preparation, and **U. N. A. D. Jayanti,** **M. N. Adlini** and **Y. N. R. Wiryawan:** review and editing.

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