



Implementing Differentiated Learning in Biology: A Practical Approach to the Independent Curriculum

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abstract

This study aims to determine the planning, implementation, inhibiting, and supporting factors, and impacts on biology subjects through differentiated learning based on learning outcomes. This study uses a qualitative case study approach to analyze the implementation of differentiated learning in the independent curriculum. Data were obtained through interviews, observations, and literature reviews, focusing on planning and implementation, as well as inhibiting and supporting factors, and their impact on learning outcomes. The results of the study show that there are 4 things in differentiated learning planning, including: 1) Teacher debriefing, 2) Lesson plan design, 3) Completion of learning tasks and activities, and 4) Final assessment and evaluation in learning. Implementing differentiated learning can increase students' motivation and learning outcomes, especially in biology subjects. Despite obstacles such as time, human resources, and access to technology, solutions such as teacher training, facility optimization, and policies can help overcome the challenges of differentiated learning. The impact of differentiated learning on biology subjects, based on learning outcomes, can be seen in increased student enthusiasm and enjoyment, as well as improved learning outcomes. In addition, students can explore material according to their interests and learning styles, and there is also a Pancasila student profile (P5).

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1. Introduction

Education is a planned effort to create a learning environment where students can actively develop their potential through the learning process. One of the learning tools that educational institutions must own is the curriculum (Sholeh, 2022). Curriculum improvements to enable students to compete and adapt to changing times. The curriculum is very important in the implementation of education because it serves as the main foundation for planning, implementing, and initiating learning, and as a strategic guideline, ensuring education that is relevant, structured, and in accordance with the needs of the times. A poorly designed curriculum can cause the educational process to lose direction and goals, affecting the quality of student learning outcomes (Hall et al., 2022).

Student-centered education is the main paradigm in creating an effective and relevant learning process. Teachers, as drivers of the learning ecosystem, not only serve as facilitators but also as leaders in independent learning oriented to students' needs and potential. In the context of biology learning, the student-centered approach emphasizes real learning experiences in which students are actively involved physically and mentally. This process not only improves scientific understanding but also builds moral principles through interaction with biological concepts relevant to their lives (Syaifuddin & Sutarto, 2013).

However, the main challenge in realizing student-centered education lies in teachers' ability to design learning strategies that accommodate students' diverse needs, learning styles, and potentials, while balancing theoretical and practical aspects. Teachers are expected to have a deep understanding of learning principles, skills in designing appropriate materials, methods, and assessments, and the ability to integrate technology to improve motivation and learning outcomes (Hamroev, 2019). The role of teachers in creating and developing learning media is indispensable in the teaching and learning process in the classroom. Teachers must be able to foster creativity. Educational challenges in the industrial era 4.0 include providing educators with the knowledge and understanding to utilize ICT (Information and Communication Technology), so that information technology in learning is expected to guide students in using ICT and facilitate the implementation of education throughout Indonesia (Hafizhah, 2021).

The independent learning curriculum was born of an evaluation and reflection on the implementation of the 2013 curriculum, which emphasizes a competency-based approach and character development. The independent learning curriculum is here to provide a wider space for teachers and students to manage learning, adjust methods to individual needs, and encourage creativity, collaboration, and innovation in the educational environment. The independent curriculum is a policy designed to address learning lag caused by various challenges, such as the legacy of the previous learning system. This curriculum aims to increase students' creativity through a more flexible, context-based learning approach.

In its implementation, the independent curriculum provides schools with the freedom to adjust the learning process to local conditions and available facilities and infrastructure. Learning can be more relevant and effective, and it can also provide space for students to develop their potential in line with each student's needs and characteristics. Implementation is the application of a policy that results in action to improve the program set (Hanifah, 2022). The implementation of independent curriculum learning requires school principals, teachers, and the community to collaborate and communicate, especially in developing curriculum and learning tools such as modules and assessments, and in understanding the independent curriculum. Teachers have demands for perfecting and developing the curriculum in line with the development of science, technology, and art (Djoeaeriah & Iskandar, 2024; Mulyasa, 2023). The design of learning plans, such as teaching modules, is often not aligned with their implementation, while teaching modules play an important role in achieving learning goals (Taqwim et al., 2020). Given the current challenges, the application of biology lesson methods can be aligned with the independent curriculum and implemented optimally. Biology is a science that investigates living things and understands life in the universe. Studying biology means understanding certain concepts rather than memorizing all the information (Aisyiyah & Amrizal, 2020). Therefore, biology learning is a discovery process that allows students to think critically and innovatively in the field of science and technology (Sitorus & Nazaruddin, 2021).

This new learning paradigm includes differentiated learning. Differentiated learning is one of the learning strategies that can be used to address students' ways of thinking, which is very important for supporting skills in the 21st century (Rahmawati, 2023). Educators can guide students to improve their self-care and strengthen their natural strengths. In the process of

"guiding, students are given freedom, but the educator is "pamong" in providing guidance and direction so that students do not lose their direction and endanger themselves.

This learning offers a holistic, adaptive education that combines academic strengths with the development of students' interests and vocational potential. In addition, learning does not focus solely on the cognitive aspect but also considers each student's interests, learning styles, and potential in various fields. Students in learning that integrates practical and theoretical aspects can create a more personalized and meaningful learning experience. Another unique feature of differentiated learning is that it can provide real-world workplace experience. This approach not only facilitates the mastery of engineering skills but also develops soft skills such as communication and cooperation. Students feel more valued and motivated to reach their maximum potential. This learning not only provides an adaptive education, but is also relevant and contextual to the needs of the local community.

Research conducted by Suhardi et al. (2023) showed that biology learning, when integrated with differentiation and problem-based learning models on metabolic systems, led to student motivation in the good category. Then, a similar study conducted by Krisnawati (2024) showed that the application of differentiation learning through three main components, namely visual, auditory, and kinesthetic, in biology subjects in high schools showed an increase in the number of students who achieved minimum accuracy criteria from cycle to cycle, increased learning motivation, and helped students to achieve better learning outcomes. Independent curriculum learning in the biology subject of the differentiated program is highly relevant and important, as it supports a holistic, adaptive educational approach that uniquely combines academic differentiation with the development of students' vocational potential. Through the integration between theory and practice, this learning not only facilitates the mastery of technical skills but also the development of soft skills such as communication and cooperation. The purpose of this study is to determine the planning, implementation, inhibiting, and supporting factors, and impacts on biology subjects through differentiated learning based on learning outcomes. The research method used in this study is a qualitative case study to explore the implementation of differentiated learning.

2. Method

The research method used in this study is a qualitative case study approach to explore the implementation of differentiated learning in the independent curriculum. This method is based on theory and analysis to provide a general picture of the research background and to serve as material for presenting the results and discussion. The primary data were obtained directly from the principal, the deputy principal, and the biology teacher. The respondents in this study are three people: the principal, the vice principal, and the biology teacher. Meanwhile, the secondary data in this study are obtained from various sources, including numerous books, journals, and the internet (Putra et al., 2022).

The purpose of literature research is to collect data and information using various sources available in the library. The data collection techniques in this study include interviews and observations conducted in July 2024 to explore planning, implementation, inhibiting, and supporting factors, as well as the impacts on biology subjects through differentiated learning based on learning outcomes. Interviews were conducted with the principal, vice principal, and biology teacher. During the observations, students' and teachers' activities were examined during learning, so that the implementation of differentiating learning was clearly visible. The data processing method uses a data reduction technique; at this stage, the researcher sorts, analyzes, and simplifies the information respondents provide in interviews about the implementation of differentiated learning.

3. Result and Discussion

Based on data from interviews and observations, the author can describe differentiated learning that focuses not only on learning products but also on the learning process and learning materials or content (Nuraini & Ramadan, 2024). In this study, the author obtained data from the research results detailed in Table 1.

Differentiated Learning Planning

The results of Table 1 show that differentiated learning planning, involving mapping students' learning needs and teacher professional development, is relevant to improving the quality of learning. By aligning needs with students' interests, learning styles, and readiness, schools can offer a focused, relevant approach. This mapping can be achieved through various methods, such as questionnaires, interviews, or observations. This approach provides teachers with detailed information to design effective learning strategies.

Table 1. Differentiated learning planning

Interview Results		Concept	Interpretation
Principal	Vice Principal		
Mapping students' learning needs, for example, in terms of interests, learning styles, and students' readiness, by asking questions or using questionnaires, etc.	Provision of teachers' professional activities through continuous training. One way workshops exist is for teachers to collaborate and share experiences to find solutions in the learning process. Teacher briefing is based on students' needs and student profile mapping.	<ul style="list-style-type: none"> - Interest - Learning style - Workshops for teachers 	Teachers are equipped through workshop activities and teacher collaboration. This collaboration between teachers can aim to share experiences and find common solutions to learning problems.
Creating differentiated teaching tools, including CP, ATP, and Modules, in which there are clear objectives, determining activities, including content, processes, and products.	The design of this lesson plan includes teaching modules and ATP that allow for adjustments to real field conditions. Design lesson plans, such as learning materials and teaching methods. Teachers can adjust the materials and methods to meet the needs of each group, providing opportunities for students to be more active in the learning process, especially through hands-on practice.	<ul style="list-style-type: none"> - Learning materials - Teaching methods 	Learning materials are in the form of modules designed for a variety of content, not only text, but also books, videos, and other visual materials that can be presented through projectors, laboratories, and other digital aids. Meanwhile, various learning methods are grouped by students' ability and interest levels.
	To complete assignments and learning activities, students are given a variety of options, including projects, presentations, and individual exercises, tailored to their	<ul style="list-style-type: none"> - Project - Presentation - Individual training 	The completion of assignments and learning activities is adjusted to each student's ability to develop skills and

	interests and strengths.		understanding. Assignment options such as individual projects, presentations, and exercises can encourage creativity and independence while allowing teachers to provide learners with feedback.
Determine reflection and follow-up activities for students.	Final assessment and evaluation do not rely solely on the final evaluation; they also integrate continuous feedback into the learning process. Research methods through a portfolio approach, evaluation skills through projects, and assessments of various types of projects.	- Evaluation	The final assessment and evaluation are designed to provide an overview of the student's development. In addition, integrate continuous feedback into the learning process.

The workshop activities for teachers aim to equip them with the latest skills and strengthen collaboration among educators. Teachers can share experiences and discuss solutions to learning challenges, thereby enriching their teaching strategies to better meet students' needs. The design of teaching tools, such as learning outcomes (CP), learning objectives (ATP), and teaching modules, is intended to be flexible and relevant to real field conditions. This arrangement adjusts teaching methods and materials to meet students' needs. The combination of various learning resources, such as text, video, and digital tools, supports a range of learning methods, thereby providing learners with opportunities to be more active and engaged, especially through hands-on practice.

The research results shown in Table 1 indicate that the challenge in differentiated learning planning is the lack of professional development and training for teachers, which limits their ability to design and implement effective learning strategies. This problem is prevalent across various educational contexts, including in South Africa and Indonesia, where teachers report inadequate training and support (de Jager, 2013). In addition, teachers often have difficulty managing classes and preparing various teaching modules, where teachers struggle to identify students' individual needs and provide varied learning materials (Nurfianto et al., 2024).

The rejection of differentiated learning methods also presents challenges, as some learners may not engage with new learning approaches (Napitupulu et al., 2023). Despite these challenges, differentiated learning has shown a positive impact on learner engagement and learning outcomes. Case studies from India and Kazakhstan show that learners increased their cognitive readiness and interest in biology subjects (Meenakshi & Sheeba, 2022). To address these barriers, education policymakers must provide more support in terms of resources, training, and workload management for teachers, so that they can effectively implement various learning strategies in biology classrooms (Lavania & Nor, 2020).

The results of research conducted by Saraya et al. (2023) show that teachers must have effective learning methods, including the ability to create lesson plans, teach in class, understand the curriculum well, and develop learning assessments. In addition, research conducted by Ibrahim et al. (2024) shows that final assessment and evaluation is the process of evaluating the

results of an activity, program, or policy. Evaluation process to find effectiveness and efficiency, quality, and motivation of learning, curriculum based on feedback or results from evaluation. Differentiated learning planning requires mapping students' needs to provide learning opportunities that are natural and efficient (Idamayanti et al., 2022). Teachers prepare learning outcomes, reference learning objectives, and modules to support differentiated learning. Teachers will create innovative learning experiences in the classroom through a learning system by designing appropriate materials, methods, media, learning resources, and environments (Suardipa & Primayana, 2023).

Implementation of Differentiated Learning

The research results in Table 2 indicate that differentiated learning in biology can increase student motivation and learning effectiveness. Teachers are given the flexibility to modify the content, processes, and learning products based on the class's student profile, including their learning styles, interests, and readiness levels. This approach helps students become more enthusiastic about learning by engaging in a process tailored to their individual needs. Furthermore, the variety of learning methods and strategies provides a more interactive and meaningful learning experience.

Table 2. Implementation of differentiated learning

Interview Results		Concept	Interpretation
Principal	Vice Principal		
Implementing differentiated learning can increase students' motivation and learning effectiveness, enabling them to learn more enthusiastically. Teachers have the opportunity and ability to adapt content, processes, and products to their students' profiles. In addition, each teacher is expected to implement differentiated learning at least 2-3 times face-to-face with students, including during the academic supervision program.	Differentiated learning, for example, in biology subjects, has been implemented. However, not all materials use differentiated learning; only certain materials do.	- Motivation Learning effectiveness	Teachers have the opportunity and ability to change content, processes, and products. The implementation of this academic supervision is carried out by the principal or deputy principal to ensure that the classroom learning process runs effectively and in accordance with the applicable educational standards.

However, the application of differentiated learning is often limited to specific materials. This may be due to limited time, resources, or inadequate training for teachers to implement this strategy consistently across the material. With a minimum of 2-3 face-to-face sessions, differentiated learning provides teachers with an opportunity to try out different strategies and evaluate the results. This process supports teachers' professional development while creating an inclusive and adaptable learning environment for students.

The research results shown in Table 2 indicate that differentiated learning requires creative teachers to guide students toward success and joy in learning (Faiz et al., 2022). According to Ellis (2010), three strategies can be effective: emphasizing students' interests, choosing the right

starting point, and allowing students to learn at their own pace. If students are less interested in the subjects taught in school, they will have little motivation to learn. Hamad's (2020) research shows that differentiated learning can improve each student's knowledge and skills in each class. This strategy can help students who fall short of the expected educational level excel in their class. However, implementing differentiated learning does not mean that all subjects can be used in this way, and only a few materials can be used effectively to enable students to be active in improving their learning.

Inhibiting factors and supporting factors for differentiated learning

The results of Table 3 show that the factors inhibiting the implementation of differentiated learning include limitations in human resources, facilities, and time. Teachers have diverse skills in technology and learning strategies, but limited time is a major obstacle, especially when covering a wide range of materials, such as biology. In Islamic boarding schools, limited access to technology and the internet limits the application of technology-based learning. Lack of parental participation is also an obstacle due to limited communication between parents and the school. As a solution, time management, teacher training, strengthening local facilities, updating relevant teaching materials, and support from school principals in motivation and policy are needed.

Table 3. Differentiated learning inhibiting and driving factors

Interview Results			Concept	Interpretation
Principal	Vice Principal	Biology Teacher		
Time in differentiated learning is limited.	Inhibiting factors include human resources, teacher characteristics, background, and skill level.	Implementing differentiated learning takes a lot of time. For example, the biology material covers many chapters, and differentiated learning is not used in every one.	- Limited time - Human resources	Human resources include teachers with varying levels of diversity in their use of technology and in the implementation of learning strategies. In addition, the time limit for implementing differentiated learning is differentiated, because biology subjects require more time and not all can be thoroughly applied in each chapter.
Facilities and infrastructure are because they are in a cottage. So, students are prohibited from bringing mobile phones.	The limitations of technological devices, such as cellphones and learning tools, are that most students use them. Santri was not introduced to operating a mobile phone.	The school is located in an Islamic boarding school environment, and due to limited internet access, students can use the computer laboratory only during lessons. And for interviews with resource persons outside the limited boarding house.	- Means - Infrastructure	The limitations of technology, such as mobile phones, pose an obstacle because Islamic boarding schools are not allowed to use them. Limited internet access is available only in computer labs during learning. In addition, when interviewing resource persons outside the boarding school, students are not allowed to leave the boarding school easily.
	Lack of parental participation, such		- Parental participati	The lack of parental participation stems from

<p>as limited communication between schools and parents, leads to a lack of understanding and support for the learning strategies implemented.</p>	<p>on</p>	<p>limited communication between schools and parents, leading to a lack of understanding and support for the learning strategies implemented. Parents cannot play an active role in supporting their child's learning; the strategies implemented do not receive optimal support from the family environment.</p>	
<p>Supporting factors, such as the updating of learning materials aligned with the latest scientific and technological developments. The books are constantly updated according to current learning. The existence of educational platforms, such as videos and simulations. This platform allows students to choose materials based on their needs and interests. The platform can also provide useful feedback to help learners measure their learning progress.</p>	<p>- Learning book update</p>	<p>Updating learning books to ensure that the material taught is always relevant to the latest developments in science and technology. Updating these books can enhance the effectiveness of learning strategies and encourage students to stay up to date with developments in their field of study.</p>	
<p>Support from schools in administration and policy.</p>	<p>The leadership of the principal and deputy principal, who always provide motivation and advice to teachers to further improve learning.</p>	<p>- School support</p>	<p>The existence of educational platforms such as videos and simulations allows students to choose material according to their needs and interests. Educational platforms also provide feedback that helps measure learning progress. This platform can help them understand the material in the most appropriate way and provide direct feedback on their understanding, so they know their abilities during the learning process.</p> <p>School support in administration includes providing resources and managing the learning process. Meanwhile, policies include regulations that support the development of better teaching methods. The motivation provided is in the form of encouragement and suggestions to help teachers explore and implement innovative and effective approaches.</p>

The research findings shown in Table 3, teachers also need to be aware of students' needs, as they are referred to as the digital generation (Hicks, 2011). The digital generation often has older teachers because they use technology appropriately and grew up in the digital age. Implementing differentiated learning in biology classrooms poses several challenges. One significant challenge is teachers' time constraints, a common problem in implementing differentiated learning strategies. Teachers often struggle to allocate sufficient time to plan and implement differentiated learning, as noted in studies from Indonesia and Malaysia, where 80% of teachers reported time constraints. Furthermore, a lack of resources and differentiated learning materials is a major barrier. This is evident in Malaysian classrooms, where resource constraints and large class sizes hinder the implementation of differentiated learning.

According to Marc Prensky, the outdated teaching methods of digital immigrants have frustrated many students, who tend to view these methods negatively. In a study by Small et al. (2009), the influence of the internet on brain function appears to be faster than reading and to have a beneficial physiological effect. In addition, data from the Semel Institute for Neuroscience and Human Behavior at the University of California-Los Angeles revealed that the brain activity of digital natives tends to increase when reading in digital format compared to print (Herther, 2009). The independent learning platform is a digital forum or an application that assists teachers in implementing the independent curriculum. The platform's goal is also to develop teacher professionals, enrich learning experiences, and provide adaptive learning.

The impact of differentiated learning in biology subjects based on learning outcomes

The results in Table 4 show that differentiated learning in biology positively impacted student enthusiasm and engagement. Students felt happier and more motivated because they could choose learning methods that suited their preferred learning styles. Furthermore, integration with the Pancasila Student Profile Strengthening Project (P5) further strengthened the positive impact of differentiated learning by providing relevant and meaningful learning experiences through practice-based activities that integrate Pancasila values, enabling students not only to deeply understand science concepts but also to develop positive character and attitudes.

Implementing practice-based P5 projects can strengthen national identity and students' character while also providing contextual, applicable learning. Differentiated learning aims to accommodate students' diverse learning needs by tailoring content, processes, and products to their interests, readiness, and learning profiles. Especially in biology subjects that require an understanding of scientific concepts to apply knowledge. This can often result in less effective learning outcomes. Based on the research mentioned above, learning is grounded in Howard Gardner's theory of multiple intelligences (Kapusnick & Haulein, 2001). Using a variety of intelligences when giving instruction, not just one or two, because learners have different ways of learning and go through many intelligences. Learners usually rely on their strongest intelligence when completing tasks (Silver et al., 2000). With this, teachers who allow students to solve problems using the intelligence that students like provide create more opportunities for students to succeed.

Table 4. The Impact of differentiated learning in biology subjects based on learning outcomes

Interview Results			Concept	Interpretation
Principal	Vice Principal	Biology Teacher		
Students are enthusiastic and happy during learning because they choose their own learning style.	The impact is that students are enthusiastic and happy during learning because they can choose their own learning style, and the Pancasila Student Profile Strengthening Project (P5) makes students more active.	Students are enthusiastic and happy during learning because they can choose their own learning style and the environment (P5), which makes them active.	- Enthusiastic - Preferred learning style - Pancasila student profile strengthening project (P5)	Adjusting learning methods to students' learning styles makes them feel comfortable, especially when choosing topics that increase motivation and interest in learning. Tailored learning can produce a positive experience for them. In addition, the Pancasila Student Profile Strengthening Project (P5) integrates Pancasila values into the curriculum through practice-based projects and activities to strengthen students' character and national identity.

The Reading-Concept Mapping-Numbered Heads Together (Remap-NHT) model is highly effective in biology education because it integrates reading comprehension with concept mapping and collaborative discussion, thereby improving students' critical thinking skills (Safitri, 2023). In addition, the Empowering Thinking with Questions (TEQ) strategy emphasizes question formulation, which enhances conceptual knowledge and critical thinking by encouraging learners to engage deeply with the content and think critically about the information presented (Nur et al., 2023). The use of textbooks based on Bloom's taxonomy, which specifically targets higher-order thinking skills, has been shown to improve students' critical thinking in biology (Ngenda et al., 2024). These strategies, if implemented effectively, can create a dynamic learning environment that fosters critical thinking skills essential to academic success in biology.

In line with Demir's (2021) research, learning tailored to learning styles is more effective than traditional teaching methods in motivating students to learn science and related subjects. The influence of differentiated learning is also applicable at the junior high school level, as it can positively affect learning outcomes, achievement, and students' critical thinking skills (Al-Shehri, 2020; Progella, 2019). In addition, research by Alsaleh (2020) and El Yazidi (2023) on collaborative learning is another effective approach, as it encourages critical thinking through peer interaction and discussion, allowing learners to explore different perspectives and refine their reasoning skills.

4. Conclusion

Differentiated learning has been proven to increase students' effectiveness and motivation, especially in Biology. This approach gives teachers the flexibility to tailor learning content, processes, and products based on students' interests, learning styles, and readiness levels. However, implementing differentiated learning poses challenges, including limited time, resources, teacher training, and access to technology, especially in environments with limited resources. Recommended solutions include ongoing professional training for teachers,

optimization of learning facilities, and time management and policies that support the implementation of this strategy. The integration of differentiated learning with the Pancasila student profile strengthening project (P5) enhances relevant, contextual learning experiences, develops students' character, and improves their critical thinking skills. In addition, applying multiple intelligence theories, collaboration, and approaches such as Remap-NHT and TEQ also significantly contribute to achieving optimal learning outcomes. Therefore, policymakers and educational institutions need to support differentiated learning by strengthening teacher capacity, providing adequate resources, and innovating in learning design to maximize impact on student development.

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