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Research Article

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Differentiated Instruction in Biology Learning: Meta-Analysis

Pembelajaran Berdiferensiasi pada Biologi: Meta-Analisis

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ABSTRACT

In the context of the 'Merdeka' curriculum and educational diversification, differentiated instruction emerges as a pivotal strategy for addressing diverse learning needs within biology education. Through a comprehensive meta-analysis, this study categorizes existing research, assesses the application across educational levels, and evaluates the impact of differentiated instruction, particularly highlighting its effectiveness in higher education facilitated by e-PJBL and learning media. The research predominantly uncovers the use of Classroom Action Research, with a notable effect size in applications at the higher education level, suggesting a marked improvement in learning outcomes. These findings call for an expanded implementation of differentiated instruction to better cater to student needs, ultimately aiming to enhance the quality of biology education across all levels.

Key words: Differentiated Instruction, Biology Learning, Meta-Analysis, Merdeka Curriculum

ABSTRAK

Dalam konteks kurikulum 'Merdeka' dan diversifikasi pendidikan, instruksi diferensiasi muncul sebagai strategi pivotal untuk menangani kebutuhan belajar yang beragam dalam pendidikan biologi. Melalui meta-analisis yang komprehensif, studi ini mengkategorikan penelitian yang ada, menilai aplikasi di seluruh tingkat pendidikan, dan mengevaluasi dampak instruksi diferensiasi, khususnya menyoroti efektivitasnya dalam pendidikan tinggi yang difasilitasi oleh e-PJBL dan media pembelajaran. Penelitian ini terutama mengungkapkan penggunaan Classroom Action Research, dengan ukuran efek yang luar biasa dalam aplikasi di tingkat pendidikan tinggi, yang menunjukkan peningkatan yang signifikan dalam hasil belajar. Temuan ini menuntut implementasi yang diperluas dari instruksi yang beragam untuk lebih baik memenuhi kebutuhan siswa, pada akhirnya bertujuan untuk meningkatkan kualitas pendidikan biologi di semua level.

Kata kunci: *Pembelajaran berdiferensiasi, Pembelajaran biologi, meta-analisis, kurikulum merdeka*

INTRODUCTION

The advent of differentiated instruction represents a significant evolution in educational pedagogy, aiming to accommodate the diverse spectrum of learners' needs within the classroom. This approach, characterized by its flexibility and adaptability, has been at the forefront of educational innovation, particularly in the context of the 'Merdeka' curriculum. The 'Merdeka' curriculum, a hallmark of educational reform, is designed to transcend the conventional, one-size-fits-all teaching models, advocating for a more personalized learning experience that reflects the unique interests, abilities, and learning trajectories of each student. The historical roots of differentiated instruction can be traced back to the 'No Child Left Behind' program in the United States, spanning from 2002 to 2015, which emphasized educational equity and access. The foundational principles and practices of differentiated instruction have been significantly influenced by the seminal work of Carol Ann Tomlinson, whose contributions to the field have helped shape contemporary educational strategies focused on learner diversity (Bondie et al., 2019; Gara et al., 2022).

In the Indonesian educational landscape, the integration of differentiated instruction is synergistic with the objectives outlined in the *Guru Penggerak Kemendikbudristek program*. This initiative, dedicated to curriculum innovation and the implementation of forward-thinking teaching methodologies, epitomizes the national commitment to advancing educational quality and inclusivity. The program underscores the importance of adapting teaching strategies to meet the heterogeneous needs of students, thereby fostering an environment conducive to optimal learning outcomes (Satriawan et al., 2021). The effective deployment of differentiated instruction hinges on the recognition of diverse student learning styles and the employment of an array of pedagogical strategies tailored to these variances (Himmah & Nugraheni, 2023; Kamalia, 2023).

The relevance and applicability of differentiated instruction in biology education have been underscored by a multitude of studies investigating its integration with various instructional models, such as Problem-Based Learning (PBL) and the use of interactive digital media. These investigations reveal the capacity of differentiated instruction to significantly enhance both the process and outcomes of biology learning, suggesting its potential to revolutionize educational practices in this field (Maulani et al., 2023; Sukmawati et al., 2023; Maulidia, 2024). The exploration of differentiated instruction in biology education not only aligns with global educational trends towards greater personalization but also addresses the specific challenges and opportunities inherent in teaching complex scientific concepts.

The impetus behind this article is to provide a comprehensive analysis of the application of differentiated instruction within the domain of biology education. By examining the spectrum of research methodologies employed, the educational levels at which differentiated instruction has been implemented, and the measurable impact of these practices, this study aims to contribute significantly to the ongoing discourse on educational reform and pedagogical innovation. Furthermore, it seeks to illuminate the ways in which differentiated instruction can be optimized to enrich biology education, thereby enhancing student engagement, understanding, and academic achievement.

Through a detailed meta-analysis, this article endeavors to map the current landscape of differentiated instruction in biology, identifying key trends, outcomes, and areas for future exploration. By situating the study within both national and international contexts, it aspires to provide educators, policymakers, and researchers with valuable insights and practical guidance on the implementation of differentiated instruction strategies. Ultimately, this investigation into differentiated instruction in biology education not only aims to advance scholarly understanding but also to advocate for educational practices that are inclusive, responsive, and conducive to the diverse learning needs of students.

RESEARCH METHOD

This study employs a meta-analysis methodology, a technique for integrating research findings to acquire comprehensive information, as outlined by Glass et al. (1981). The sample for this research comprises 7 national journal articles focused on differentiated instruction in biology (Table 1). The research procedure involves formulating the problem, gathering relevant literature, collecting information from the literature, evaluating the quality of the literature, analyzing data, interpretation, and presenting the results, following the framework suggested by Cooper (2017).

Table 1. Samples of Articles from National Journal about Differentiated Instruction in Biology Subject

No	Author	Year	Research Type	Learning Strategy	Topic	Education Level
1	Minasari dan Susanti	2023	Qualitative	Problem based Learning	Circulatory System	High School
2	Maulani, et al.	2023	CAR	Problem based Learning Lesson study	Ecosystem	High School
3	Shafira, et al.	2023	CAR	Problem based Learning	Ecosystem	High School
4	Sukmawati, et al.	2023	Quasi experiment	e-PJBL assisted H5P media	Biology	University
5	Tika, et al.	2023	R and D	Three Tier Diagnostic Test	Excretory System	High School
6	Afelia, et al.	2023	CAR	Problem based Learning	Environment	High School
7	Maulidia, et al.	2024	CAR	Problem based Learning	Human Immune System	High School

The measurement of effect size was conducted using the criteria outlined in Table 2, following the calculation of the specified formula:

$$\Delta = \frac{\bar{x}\ eksperimen - \bar{x}\ kontrol}{SD\ kontrol}$$

Table 2. Effect Size Criteria (Glass, et al., 1981).

Value of Effect	Category
1,45 < effect size	Excellent Effect
1.10 < effect size ≤ 1,45	Really Big Effect
0,75 < effect size ≤ 1.10	Big Effect
0,40 < effect size ≤ 0,75	Moderate Effect
0,15 < effect size ≤ 0,40	Small Effect
effect size ≤ 0,15	Ignored

RESULT AND DISCUSSION

Type of Research

Upon analyzing the 7 articles, four separate categories of study were identified: qualitative research, quasi-experimental research, research and development (R&D), and classroom action research (CAR). The occurrence of these types varied, with the highest being CAR at 57%, and the lowest being qualitative and quasi-experimental research (Figure 1).

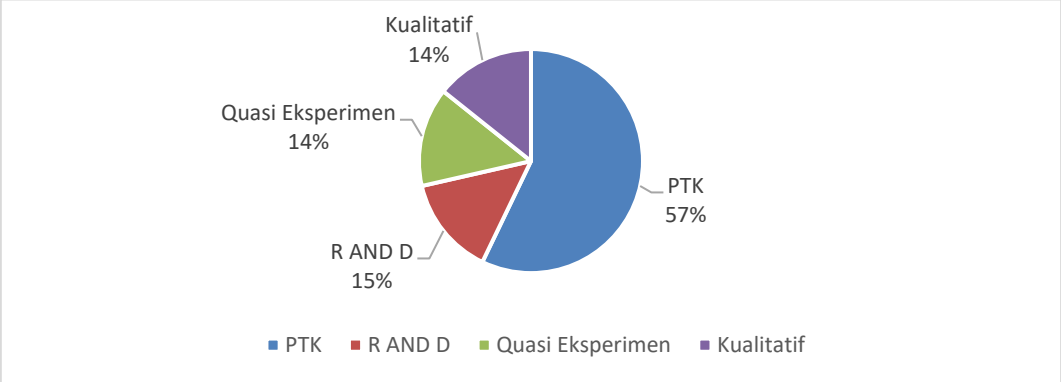

Figure 1. The distribution of the types of research of Differentiated Instruction in Biology Learning

Classroom Action Research (CAR) is the predominant form of study carried out while implementing differentiated instruction in classrooms. Classroom Action Research (CAR) is an educational research method carried out by instructors in the classroom, with the specific aim of improving and perfecting instructional procedures, as described by Arikunto (2013). The extensive usage of CAR in differentiated biology instruction research may be attributed to various factors. Firstly, it is aimed at enhancing the quality of learning. Secondly, it incorporates novel teaching approaches. Lastly, it applies scientific principles in the learning process (Arikunto, 2017).

Education Level of Differentiated Instruction Application

Table 2. Effect of Differentiated Learning in Biology Subject

No	Educational Level	Frequency	Percentage
1	High School	6	85,7%
2	University	1	14,2%

The analysis of selected articles shows that high schools were primarily used as settings for research. This trend aligns with the efforts to implement the 'Merdeka' curriculum, especially in the Guru Penggerak program, as pointed out by Satriawan et al. (2021) and Faiz et al. (2022). Although differentiated instruction can be adapted for all educational levels, from elementary to higher education, its effective implementation largely depends on key factors. These include recognizing student characteristics, performing diagnostic assessments, and skillfully using a variety of teaching methods, from multiple methods to multimedia use, as emphasized by Purnawanto (2013).

Effect Size of Differentiated Instruction in Biology Learning

An ensuing study was performed to ascertain the magnitude of the impact resulting from the implementation of differentiated biology instruction. The combination of the e-PJBL paradigm and

instructional media resulted in a significantly high effect size (1,21) for learning outcomes. However, for other implementations, there was a lack of data to determine the magnitude of the learning accomplished (Table 3).

Table 3. Distribution of Learning Strategies Used

No	Learning Strategy	Frequency	Percentage	Δ	Level
1	Problem-based Learning	5	71,4%	-	High School
2	e-PJBL assisted by H5P	1	14,2%	1,21	University
3	Three Tier Diagnostic Test	1	14,2%	-	High School

Table 3 reveals that the implementation of biology differentiation instruction at the university level (Universitas Tidar) using collaborative models and media resulted in a "very high" effect size. Undoubtedly, this provides a reliable sign of the implementation of differential instruction. Meanwhile, the problem-based learning methodology is predominantly utilized in high schools. Typically, the purpose of applying learning at the high school level is to achieve enhanced learning outcomes with each completed cycle.

Furthermore, apart from traditional classroom learning, there is also differential instruction through the creation of diagnostic test tools. The inclusion of differential instruction in a teacher's preparation indicates its crucial significance, likely due to its urgent importance (Purnawanto, 2023).

CONCLUSION

The research findings indicate that class action research is the predominant approach used in biology differentiation learning research, accounting for 57% of the studies conducted. The implementation of its acquired knowledge is predominantly carried out in high school or equivalent education, accounting for 85.7%. The implementation of biology differentiated instruction in high school is combined with the problem-based learning paradigm, although it has not demonstrated any significant effect size. The partnership between the e-PJBL paradigm and learning media in higher education demonstrates a significant effect size categorized as "very high". Additional research is required to explore the broader implementation of differentiation instruction in biology subject, with the aim of obtaining insights to enhance the quality of classroom instruction.

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