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Enhancing Student Higher Order Thinking Skills through Problem-Based Learning Media Integration

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Abstract: Enhancing Student Higher Order Thinking Skills through Problem-Based Learning Media Integration. Objectives: This quantitative research employed a quasi-experimental non-equivalent control group design to investigate the impact of Problem-Based Learning (PBL) media on student higher order thinking skills (HOTS). **Methods:** The research was conducted with students from XI IPA 3 and XI IPA 4 classes at a high school. **Findings:** Students using PBL-based media exhibited a mean score of 83 for HOTS, with a notable n-gain of 0.7, categorized as high. In contrast, the control group achieved an average posttest score of 74.1, accompanied by an n-gain of 0.5, classified as medium. Statistical analysis indicated a t-value of 4.376, signifying a significant effect of PBL media on students' HOTS. Implementing the PBL-based media in the learning process was highly successful, achieving an average implementation percentage of 100% with excellent criteria. **Conclusion:** These findings affirm the positive influence of PBL-based media on students' HOTS, underlining its potential as an effective teaching strategy.

Keywords: higher order thingking, learning media, problem-based learning.

Abstrak: Meningkatkan Keterampilan Berpikir Tingkat Tinggi Siswa Melalui Integrasi Media Berbasis PBL. ***Tujuan:*** *Penelitian kuantitatif ini menggunakan metode quasi-eksperimental non-equivalent control group design untuk mengetahui pengaruh media berbasis PBL terhadap keterampilan berpikir tingkat tinggi siswa.* ***Metode:*** *Penelitian dilakukan terhadap siswa SMA kelas XI IPA 3 dan XI IPA 4.* ***Temuan:*** *Hasil posttest menunjukkan bahwa siswa yang menggunakan media berbasis PBL menunjukkan nilai rata-rata HOTS sebesar 83, dengan n-gain sebesar 0,7, termasuk dalam kategori tinggi. Sebaliknya pada kelompok kontrol memperoleh rata-rata skor posttest sebesar 74,1 disertai n-gain sebesar 0,5 yang tergolong sedang. Analisis statistik menunjukkan nilai t = 4,376 yang berarti terdapat pengaruh yang signifikan media berbasis PBL terhadap HOTS siswa. Penerapan media berbasis PBL dalam proses pembelajaran sangat berhasil, mencapai rata-rata persentase keterlaksanaan sebesar 100% dengan kriteria sangat baik.* ***Kesimpulan:*** *Temuan ini menegaskan pengaruh positif media berbasis PBL terhadap Keterampilan Berpikir Tingkat Tinggi siswa, menggarisbawahi potensinya sebagai strategi pengajaran yang efektif.*

Kata kunci: *berpikir tingkat tinggi, media pembelajaran, pembelajaran berbasis masalah.*

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INTRODUCTION

The dynamic landscape of education continuously adapts to technological advancements and evolving pedagogical approaches. Acknowledging the pivotal role of educators in this transformation, particularly in the digital era, Sulistyani (2020) emphasized the significance of proficient teachers in understanding and harnessing technological changes. In this developing phase of the digital age, professional educators wield substantial influence in the realm of education, enabling the convergence of virtual and classroom-based learning opportunities.

Developing students' critical thinking, creativity, and problem-solving skills must be a top priority for educational institutions in the twenty-first century (Pratiwi, Dewi, & Paramartha, 2019). The Fourth Industrial Revolution and the rapid expansion of information have created new challenges, and these skills—collectively referred to as Higher Order Thinking Skills (HOTS)—are essential for doing so (Driana & Ernawati, 2019). To prepare pupils for the complicated requirements of the modern world, they must become proficient in these skills.

Indonesia's participation in the Program for International Student Assessment (PISA), which assesses advanced thinking skills, including creativity, unveils an average scientific proficiency ranking (SCIENCE) score of 396 for Indonesian students in 2018. Notably, Indonesia's 2018 PISA score ranked 74 out of 79 particscience ting countries, underscoring the imperative to bolster students' Higher Order Thinking Skills (Asrinan, 2020). The uneven quality of national education has been identified as a primary factor contributing to this deficiency in students' thinking abilities.

A contextual assessment at high school, including interviews with biology teachers, uncovered a pressing need to enhance students' cognitive learning outcomes, particularly in Higher Order Thinking Skills (HOTS). Many students struggled to meet the Minimum Passing Grade (KKM) on daily assessments, especially those involving essay questions or descriptive responses. It was apparent that many students lacked the requisite HOTS. This observation was corroborated by an analysis of student learning outcome documents, revealing that 62% of students struggled to answer questions demanding higher order thinking. Moreover, student interviews underscored the challenges associated with learning biology, precisely the immune system material, due to its complexity, volume, and limited teaching methods.

Numerous factors influence students' development of HOTS, with the learning process being a key determinant. The teacher's competency and the availability of conducive learning environments further shape this process. Consequently, diversifying teaching methodologies is an effective strategy for enhancing students' HOTS. Research conducted by Fitri revealed that problem-based learning significantly improved students' comprehension of concepts and heightened their engagement in the learning process. The positive correlation between teacher-student interactions and student comprehension underscored the efficacy of problem-based learning (Fitriani, 2020). In line with these findings, Rahayu et al. (2021)demonstrated the efficacy of electronic-based media in enhancing students' HOTS, asserting its superiority over conventional learning materials such as textbooks. Similarly, Pia and Masnur (2021) confirmed the positive impact of the PBL model on students' HOTS, emphasizing its transformative potential compared to traditional teaching methods.

The immune system subject is a major component of biological education for high school students in the eleventh grade, according to the 2013 curricula. Not only is mastery of this material critical for academic development, but it also helps develop the vital life skills required to guard

against various infections. But as Raida (2018) points out, learning this subject presents particular difficulties because of its complex ideas and substantial material.

Integrating Information Technology (IT) into problem-based learning offers a promising avenue for infusing innovation into education. Such an approach aligns with the demands of the contemporary era. It complements the PBL model's five-step framework, encompassing problem orientation, learning organization, guided investigation, results development and presentation, and process evaluation (Fatmawati, 2022). By combining PBL with IT-based media, students can harness their innate capabilities to formulate novel concepts and consolidate their understanding of the subject matter (Ambarwati & Kurniasih, 2021).

Advancements in science and technology have enabled the development of interactive and captivating learning media in print and digital formats. These engaging learning tools facilitate better retention and absorption of educational content, augmenting students' overall learning experience. Beyond achieving academic excellence, the ultimate goal is for students to internalize and apply acquired knowledge in their daily lives (Ekayani, 2017). The fusion of PBL-based media with biology education, particularly on the immune system material, offers a compelling strategy for nurturing Higher Order Thinking Skills among students. This research investigates the influence of PBL-based media on developing Higher Order Thinking Skills in eleventh-grade high school students in response to educational challenges and opportunities.

Higher Order Thinking Skills (HOTS) are becoming increasingly crucial as pedagogical techniques and technology evolve in education. Higher order thinking skills, or HOTS, comprise critical thinking, creativity, and problem-solving. In the digital age, Sulistyani (2020) underlined that educators play a critical role in comprehending and exploiting technology advances. Due to the new problems created by information advancements, the Fourth Industrial Revolution, and other factors, these talents are becoming increasingly important (Driana & Ernawati, 2019). Pratiwi et al. (2019) emphasized the requirement that educational institutions provide students with HOTS to meet the expectations of the twenty-first century. Participation in the Program for International Student Assessment (PISA) in Indonesia demonstrates the significance of higher order thinking abilities, including creativity. However, Indonesia's PISA 2018 performance demonstrates the urgent need to enhance students' HOTS skills (Asrinan, 2020).

Although the significance of HOTS is acknowledged worldwide, Indonesia still has difficulties instilling these abilities in its pupils. According to a contextual assessment at the high school level, many students lacked the necessary HOTS since they frequently struggled to meet the Minimum Passing Grade (KKM) on daily assessments, particularly in essay questions or descriptive responses (Sulistyani, 2020). The findings of document analysis of student learning outcomes, which indicate that 62% of students had difficulties answering problems requiring high-level thinking, support this as well. To overcome this difficulty, it is crucial to consider factors that affect students' HOTS development, including the learning process, teacher competency, and a conducive learning environment (Fitriani, 2020).

Several efficient learning strategies are required to overcome the difficulties in developing HOTS. Problem-based learning (Problem-Based Learning) has been shown to significantly boost students' conceptual knowledge and engagement in the learning process, according to research by Fitri (2020). According to a study by Rahayu et al. (2021), electronic-based media is more effective at raising students' HOTS than traditional learning resources like textbooks. This

finding is consistent with that research. The favorable effect of the problem-based learning (PBL) paradigm on students' HOTS was further confirmed by Pia & Masnur (2021). Therefore, problem-based learning (PBL) and information technology (IT) integration offer the possibility for educational innovation that satisfies the needs of the modern day.

A learning strategy known as problem-based learning (PBL) has been shown to help students build their higher order thinking skills (HOTS). In the context of this study, "PBL" refers to a teaching strategy in which students are exposed to complicated situations or real-world problems that call for problem-solving and critical thinking. PBL strongly emphasizes students' active participation in recognizing, examining, and solving these challenges (Fitriani, 2020). PBL is crucial because students must think creatively, thoroughly analyze material, and deal with difficult challenges to succeed in 21st-century education (Pratiwi et al., 2019). Fatmawati (2022) states that the five-step PBL framework consists of problem orientation, learning organization, guided inquiry, development and presentation of outcomes, and process assessment.

PBL offers various benefits for helping kids develop their HOTS. According to research by Fitriani (2020), PBL significantly improved students' conceptual understanding and promoted active participation in the learning process. PBL promotes critical thinking, problem-solving, and the development of original ideas among pupils. Similar conclusions were supported by Rahayu et al. (2021), who discovered that PBL increased students' HOTS. Through the investigation of real-world issues, this learning paradigm offers students the chance to refine their higher-order thinking skills.

PBL is employed in this research as a learning approach to get around the difficulties of learning complicated immune system content that necessitates in-depth conceptual comprehension (Raida, 2018). PBL integration can improve students' comprehension of complex subjects while helping them refine their HOTS. Therefore, it is anticipated that the PBL approach backed by IT-based media will be a successful method for helping students master challenging subjects while also enhancing their capacity for higher-order thinking.

Higher Order Thinking Skills (HOTS) initiatives strongly emphasize the value of learning resources. According to Mulyani, Sujarwanta, & Asih (2018), educational media can increase student engagement and foster critical thinking. Surya's research from 2021 further shows that the utilization of learning media improves students' comprehension of the course material. According to Wahyuni (2020), physical and digital learning media provide opportunities for pupils to develop their analytical and creative skills.

Learning materials based on information technology (IT) have created new possibilities for student HOTS development. Adi's research (2023) demonstrates that IT-based learning materials like computer simulations and instructional films can encourage students to think critically. Students can access more educational resources and engage in project-based learning when they use IT-based media, according to Wijaya (2022). This is consistent with other research results that highlight the advantages of IT-based learning media in enhancing students' comprehension of difficult topics and problem-solving skills (Nugroho, 2021).

An intriguing way to teach content about the immune system is to combine interactive learning materials, particularly IT-based ones, with a Problem-Based Learning (PBL) methodology. PBL is assisted by IT-based learning media, according to recent research (Anggraeni, 2023), which reveals that this helps students to explore freely, work together to solve problems, and take on challenging critical thinking tasks in complicated subjects. The findings of this

study are consistent with those of Darmawan (2022), who emphasized that using PBL in conjunction with IT-based media enables students to build HOTS effectively and offers a more profound learning experience.

This study assesses how employing PBL (Problem-Based Learning) media affects class XI students' Higher-Order Thinking Skills (HOTS). Additionally, this study compares the HOTS performance of groups of students who use PBL-based media to control groups who do not. Additionally, this study aims to gauge how much PBL-based media has been incorporated into the teaching and learning process and how well students have responded. Hopefully, this study's findings will help people better understand how PBL-based media can be used as a teaching tool to help students develop their HOTS.

METHODS

This study adopts a quantitative research approach, employing quasi-experimental methods to investigate the impact of PBL-based media on students' Higher Order Thinking Skills (HOTS). The research design selected for this study is the Nonequivalent Control Group Design, which involves two distinct groups: the experimental class and the control class, each receiving different instructional treatments. The experimental group experiences PBL-based media instruction, while the control group follows a conventional learning approach. The study's population comprises high school students.

A sample of 70 participants was selected using random sampling techniques. The subjects were divided into two groups: the experimental group, consisting of 36 students, and the control group, comprising 36 students. Ethical considerations were upheld, with all participants providing informed consent. Data collection methods employed in this research encompassed standardized tests and measurements.

The primary instrument used was an essay test with roughly 15 questions, 9 of which were classified as C4 questions and 6 as C5 questions. An assessment rubric for higher-order thinking skills (HOTS) was used in these questions. The essay questions, which concentrated on the indicators of "Analyse" and "Evaluate" for both C4 and C5 categories, were modified from several daily quiz activities. Testing for reliability and validity was done on the test items. Students were graded following the assessment criteria, which aligned with HOTS skill indicators pertinent to the immune system content.

Observation sheets were used with the essay test to assess student participation and activity levels during Problem-Based Learning (PBL) sessions that included media. The effectiveness of PBL-based media was evaluated by asking students questions and recording their answers. Post-test results were given to students after the instructional interventions to gauge how the PBL-based media affected their higher-order thinking skills (HOTS).

Data analysis consisted of several steps. Initially, a descriptive analysis was conducted, followed by pre-analysis assessments, including the Normality Test and Homogeneity Test, to ensure data met the requisite assumptions. Subsequently, statistical analysis, comprising the Independent T-Test using SPSS and the N-Gain test performed with Microsoft Excel, was employed to ascertain the effects of PBL-based media on students' Higher Order Thinking Skills.

RESULTS AND DISCUSSION

The pretest served as a pivotal benchmark in this research, strategically implemented to ascertain the initial extent of students' Higher Order Thinking Skills (HOTS). It provided a comprehensive evaluation of students' foundational abilities before delving into the intricacies of the immune system material. The

subsequent presentation of pretest scores for both the experimental and control groups can be observed in Table 1, elucidating the baseline HOTS proficiency levels of the participants before the intervention. This preliminary assessment laid the groundwork for thoroughly examining the impact of PBL-based media on enhancing their HOTS throughout the study.

Table 1. Student hots pretest results

Class	Highest Score	Lowest Score	Total	N	Average
Experiment	66	22	1911.1	36	51.8
Control	67	22	1820.0	36	51.0

The data in Table 1 regarding the pretest outcomes reveal that the control and experimental groups exhibited relatively low average scores. This indicates that students in both classes initially possessed limited proficiency in Higher Order Thinking Skills (HOTS). Subsequently, following the acquisition of the average pretest scores, we conducted assessments to determine the normality and homogeneity of the data, ensuring that the prerequisites for further analysis were met. These evaluations played a vital role in establishing the suitability of the dataset for subsequent statistical procedures, laying the foundation for the rigorous examination of the impact of PBL-based media on students' HOTS development throughout the study.

The assessment of students' initial and concluding Higher Order Thinking Skills (HOTS) within the experimental and control classes was accomplished by administering test questions. Each class consisted of 36 students, amounting to a total of 72 participants. The tabulated data illustrating the measurements of HOTS among students from both the experimental and control classes at High School is meticulously presented in Figure 1, providing comprehensive insights into the performance of these students.

This table encapsulates the comparative analysis of HOTS development, offering a detailed breakdown of students' initial and final skill levels. It serves as a valuable reference point for evaluating the impact of the PBL-based media intervention on enhancing students' higher-order thinking abilities. The data presented in Figure 1 will be further examined and interpreted to draw meaningful conclusions regarding the efficacy of the teaching approach in elevating students' HOTS.

Table 2. Data of measurement of experimental class and control class

Description	Class			
	Experiment		Control	
	Before	After	Before	After
C4				
Lowest Score	22	56	22	44
Highest Score	67	100	67	100
Total	1911.1	3011	1889	2688
Average	53.1	84	52	74
C5				

Lowest Score	20	40	20	53
Highest Score	67	100	66.7	100
Total	18.20	2980	17.66	2647
Average	50.6	83	49.1	74
Total Amount	3731.1	5591	3656	5335.6
Average	51.8	83	51.0	74.1
Average Gain Score	0.7		0.5	
Category Average Gain Score	High		Moderate	

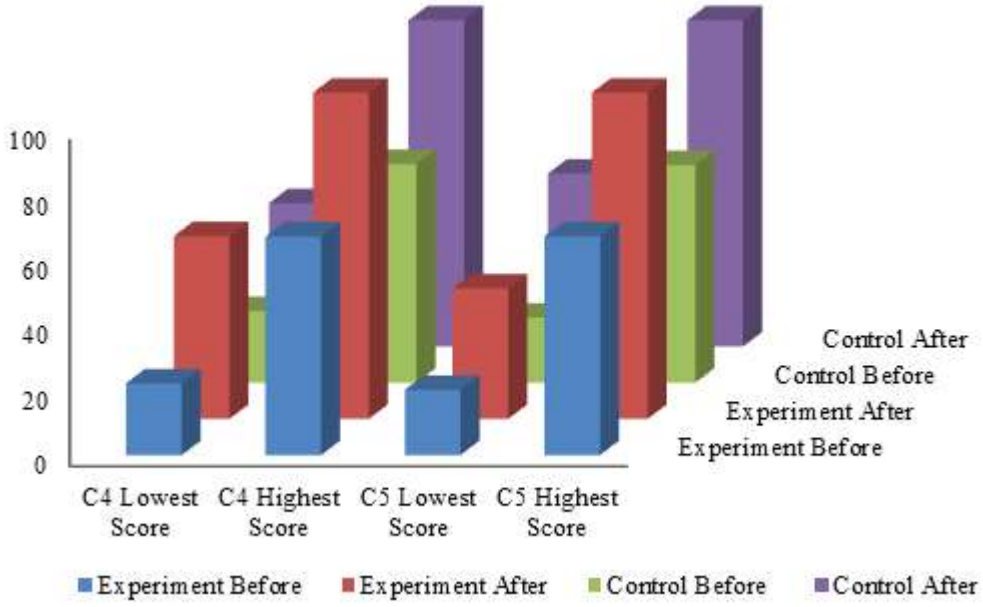

Figure 1. Data of measurement of experimental class and control class

The data presented in Table 2 provides valuable insights into the posttest scores, showcasing a noteworthy improvement in the experimental class compared to the pretest scores. An average N-Gain calculation of 0.7, categorized as "high," underscores the significant enhancement in the Higher Order Thinking Skills (HOTS) of students in the experimental group. In contrast, the control class exhibited an N-Gain of 0.5, placing it within the "medium" category. This disparity signifies that students exposed to the PBL-based media intervention witnessed a more substantial increase in their HOTS abilities than their counterparts in the control group.

Higher Order Thinking Skills (HOTS) among students in both experimental and control classrooms significantly improved after the learning process, according to the data

description supplied. Notably, there is a noticeable differential favoring the experimental class in the increase in HOTS between these two groups. This variation in HOTS improvement points to a considerable discrepancy in the efficacy of the instructional strategies used in the experimental and control classes. More specifically, compared to their counterparts in the control class, members of the experimental class showed a much larger average gain in HOTS.

The results demonstrate how Problem-Based Learning (PBL) media can help students develop their Higher Order Thinking Skills. PBL seems to be an effective instructional strategy because it involves students in real-world issues and challenges them to think critically, analyze circumstances, and develop novel solutions. As shown in Figure 1, the observable outcomes support the idea that integrating PBL-based media in teaching techniques can significantly improve students' cognitive abilities.

After conducting the prerequisite requirements analysis, the subsequent step involved hypothesis testing. This examination aimed to determine whether using PBL-based media significantly impacts students' development of Higher Order Thinking Skills (HOTs). In testing this hypothesis, the study employed a t-test. The HOTS assessments obtained from students yielded a t-count value of 4.376. This value was compared with the t-table value at a significance level of 0.05, which equates to 2.030. The comparison revealed that t-count > t-table and the two-tailed significance value (sig.) was 0.000 < 0.05.

Table 2. Results of the hots assessments

Results of the HOTS Assessments	
t-count	4.376
t-table 0.05	2.030
Sig value	0.000<0.05

Therefore, it can be conclusively stated that the Alternative Hypothesis (Ha) is accepted, signifying a significant difference in the use of PBL-based media developed for the immune system material in enhancing HOTs among students in the experimental class when compared to students in the control class who did not utilize the developed PBL-based media. These findings align with prior research indicating that Problem-Based Learning (PBL) approaches can enhance students' higher-order thinking skills (Misra, 2020). This is consistent with the concept that interactive and problem-solving-oriented media, such as the PBL approach, stimulate students' minds and improve their critical and creative thinking abilities (Bao, 2019).

In the context of this research, the learning activities involving PBL-based media were closely monitored by observers. The PBL model utilized in this study encompassed several stages that students and teachers executed throughout the learning process. These stages were meticulously assessed using teacher and student observation sheets, which have been acknowledged as essential tools for evaluating the overall feasibility of the learning process as outlined in the RPP (Lesson Plan) (Putri, 2020).

The implementation of the learning process utilizing PBL-based media unfolded throughout four class sessions. It is worth noting that the success of learning activities conducted with PBL-based media was contingent upon their alignment with the predefined steps delineated in the RPP, which essentially revolves around adhering to the PBL syntax. The learning implementation soared to an impressive 100% in

the field trials. This can be attributed to the careful and competent execution of the learning process by the teacher, who meticulously adhered to the syntax of the lesson plan (RPP). Additionally, the RPP was an invaluable guide throughout the research, steering all learning activities in the desired direction.

Furthermore, teachers' profound understanding of the media and the provided materials complemented this adherence to the learning sequence. This enabled the seamless alignment of the learning activities with the intended objectives. In essence, teachers followed the learning sequence and ensured that the learning content and media were effectively incorporated into the pedagogical process. Moreover, the classroom environment in which these activities took place was deemed conducive, aligning with the findings of Ahmad and Nidzam (2017), who underscored the pivotal role of a conducive learning environment. Such an environment is instrumental in fostering a sense of comfort, security, and enjoyment among students, ultimately enhancing their learning experiences (Tisza, 2021).

In pedagogy, teachers are indispensable in preparing students to engage with lessons effectively. This includes cultivating students' readiness to receive and absorb new knowledge. Providing apperception, which is the process of preparing students mentally for upcoming lessons, is a pivotal step in motivating students to be attentive and enthusiastic learners. This approach aligns with the research conducted by Carless (2018), emphasizing the significance of apperception in building students' enthusiasm for learning, thus promoting focused attention and active engagement.

As the research delved deeper into the control class, it became evident that the implementation of learning activities also met high criteria. However, the initial meeting witnessed certain stages or steps the teacher did not fully realize, implying suboptimal achievement of specific learning stages. An in-depth analysis revealed that some critical elements, such as communicating the learning objectives and conducting evaluations, had been omitted during the initial meeting. This finding concurs with the insights provided by Al-Fraihat (2019), who emphasized the importance of providing evaluations in the learning process. Evaluations serve as essential feedback mechanisms through which students can gauge their progress and their success level during the learning journey.

In the subsequent meeting, teacher and student activities exhibited high criteria, indicating an improvement in the overall execution of the learning process in the control class. This indicates a positive trajectory and an opportunity for further refinement and optimization of the pedagogical approaches employed in the control class. Enhancing students' High Order Thinking Skills (HOTS) is of paramount importance in the field of biology education. The assessment of students' HOTS is based on pretest and posttest scores conducted at the commencement and culmination of the learning activities, employing the N-Gain formula to discern the comparison of students' cognitive learning outcomes. Students' achievements are delineated based on the Competency Achievement Indicator (GPA) in the immune system subject matter context.

Data derived from the analysis of students' HOTS using PBL-based media indicate a notable improvement, with an average pretest score of 51.8 and a posttest score of 83, resulting in an N-Gain of 0.7, categorized as high. This corroborates with the findings of Jailani (2017), highlighting the effectiveness of the PBL model in elevating students' HOTS. The PBL model's efficacy lies in exposing students to real-world problems encountered in daily life, thereby honing their higher-order thinking skills.

The results of the Independent test and t-test applied to students' HOTS yielded a

significance value of p < Q (0.000 < 0.05), signifying the acceptance of the alternative hypothesis (Ha) and substantiating a significant difference between the use of PBL-based media products developed for the immune system material in the experimental class compared to traditional learning in the control class. This aligns with the viewpoint of Abdurrozak et al. (2016), emphasizing that the PBL model empowers students to grapple with genuine problems, fostering innovative solutions and higher-level thinking in the process. This notion is further validated by Simanjuntak's (2021) research, which posits that PBL-based learning encourages students to tackle questions arising during problem-solving, thereby cultivating innovative ideas. In conclusion, PBL-based media integration has been proven effective in enhancing students' HOTS. According to Sarrab (2012), electronic media in learning endeavors can optimize students' participation by shifting the focus toward student-centered or learner-centric approaches.

Using smartphones is advantageous in supporting students' learning activities, streamlining communication between peers and educators, thus saving time. This is congruent with the findings of Bidaki (2013), which underscore the role of technology in enhancing students' independence by facilitating information retrieval, augmenting motivation, and aiding problem-solving processes. In a similar vein, Shimizu (2019) suggests that technology-driven information access enhances problem-solving effectiveness and fosters HOTS among students. The development of PBL-based media is further enriched with supplementary information aimed at bolstering students' knowledge regarding daily challenges associated with the body's defense mechanisms.

In the control class, students' HOTS abilities also experienced growth, although at a relatively lower rate. This progress was achieved through conventional lecture-based instruction, resulting in a posttest score 74.1. Notably, the average N-Gain in the control class was 0.5, denoting a moderate level of improvement but falling short of the gains observed in the experimental class.

The somewhat limited improvement in students' HOTS within the control group can be attributed to a superficial understanding of the subject matter, impeding their ability to articulate thoughts and ideas effectively in written assessments featuring HOTS indicators. The traditional lecture-based teaching approach tends to be teacher-centered, leading to student disengagement and hindering comprehensive comprehension of the immune system material. Rankapola (2023) affirms that passive learning environments hamper students' exploration of creative ideas in problem-solving scenarios. The passive nature of learning through lectures, prevalent in the control class, tends to render students less active and impede their ability to grasp the presented material fully.

In the educational realm, instructors and educational institutions must consider pedagogical methods supporting students' higher-order thinking skills, such as incorporating student-centered approaches like PBL-based media. This research underscores the significance of technology, such as smartphones, in facilitating more engaging and effective learning experiences. By doing so, educators can nurture the growth of students' HOTS, ultimately preparing them to effectively confront the challenges of our complex world.

The research findings from the experimental class using PBL-based media and the control class using the traditional lecture method on the immune system material yielded distinct outcomes. In the control class, student responses concerning the implementation of learning were moderate, with an average score of 72.25%. However, a different picture emerged in the experimental class, where student responses to

learning with PBL-based media garnered an impressive average of 87.6%, falling within the very strong category. This higher average signifies that students reacted positively to and appreciated using PBL-based media in their learning experiences.

This positive response aligns with the perspective of Mireles-Rios (2019), who argues that teachers who select appropriate learning media elicit favorable responses and boost student engagement. Beyond selecting suitable media and instructional models, positive responses are influenced by how well teachers handle these resources during instruction. Student reactions to PBL-based media can be attributed to students' active role in their learning, feeling that they are integral to the learning process. This contrasts with the conventional lecture-based learning observed in the control class.

PBL-based media imparts a sense of motivation and enthusiasm among students during their learning endeavors. As students feel more invested and motivated, they are better positioned to grasp the material thoroughly. Anwar et al. (2022) share that increased student motivation results in enjoyable and fulfilling learning experiences, leading to optimal performance and achieving learning objectives per curriculum expectations.

Furthermore, when examining the impact of PBL-based media, it is vital to consider the role of technology and electronic devices in modern education. Smartphones, for instance, have proven beneficial in supporting students' learning activities. They save time and facilitate communication among students and between students and teachers. This perspective is corroborated by Bidaki (2013), who emphasizes that using devices enhances students' independent learning, supports information retrieval activities, boosts motivation, and aids in problem-solving processes. Shimizu (2019) also argues that technology aids in accessing information, enhancing problem-solving abilities, and nurturing HOTS among students. The development of PBL-based media supplemented with additional information helps students better understand everyday issues related to the body's defense mechanisms.

In the control class, where traditional lecture-based methods were employed, students demonstrated improved HOTS abilities. However, this improvement was less pronounced than in the PBL-based media class. Hardiansyah's study (2022) found that employing limited variations in instructional models can lead to suboptimal learning outcomes, as students tend to be less active in their learning. The data from the N-Gain calculations corroborate this trend, with the control class achieving an average N-Gain of 0.5, which falls within the medium category but is lower than the average obtained in the experimental class.

The lower levels of student HOTS observed in the control class can be attributed to inadequate comprehension of the subject matter, making it challenging to articulate thoughts and ideas effectively in written responses requiring HOTS indicators. The conventional lecture-based approach, which is more teacher-centered, tends to bore students and hinder them from comprehending the complex immune system material. Hsia (2021) contends that passive learning environments limit students' opportunities to explore creative ideas when addressing presented problems. Consequently, the lack of student involvement in the control class results in passivity and comprehension difficulties related to the material presented. Effective teaching practices must consider the various learning components, such as learning objectives, teachers, students, methods, media, learning resources, and evaluation. When well-coordinated, these components reinforce one another and contribute to learning success.

In conclusion, the research findings indicate that PBL-based media significantly enhances students' HOTS abilities. These findings are consistent with prior research on the effectiveness of PBL models in promoting higher-level thinking. Furthermore, the positive student responses to PBL-based media can be attributed to students' active role in their learning experiences, fostering motivation and enthusiasm. Technology, particularly smartphones, also plays a supportive role in modern education, facilitating communication, saving time, and aiding in problem-solving processes. The development of PBL-based media augmented with supplementary information helps students better grasp issues related to the body's defense mechanisms.

Using conventional lecture-based methods, the control class also demonstrated improved HOTS abilities, albeit to a lesser extent than the experimental class. This disparity can be attributed to the limitations of traditional teaching methods in promoting active learning and creative problem-solving. Adopting more diverse and engaging instructional approaches, such as PBL-based media, is essential to maximize learning outcomes and foster higher-level thinking.

■ CONCLUSIONS

The study's findings show that, compared to conventional lecture-based teaching techniques, PBL-based media, particularly the Problem-Based Learning approach, improves students' Higher-Order Thinking Skills (HOTS). The use of PBL-based media in teaching immune system information demonstrates its superiority, and student reactions to this media have been overwhelmingly positive. This achievement highlights the value of creative teaching methods in light of how the educational landscape has changed in the digital age. PBL-based media is a valuable tool for educators who want to equip their pupils with critical thinking and problem-solving skills, as these skills are vital for intellectual development and adaptation in a constantly changing society.

The study also points out that, despite the findings supporting the effectiveness of PBL-based media in raising student HOTS, this study is still open to additional investigation using alternative techniques. Appreciating the potential of PBL-based media as a successful teaching technique on a deeper and more in-depth level is crucial. Therefore, future studies may yield more knowledge and a deeper comprehension of how to enhance students' higher-order thinking abilities in academic settings.

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