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Analysis of Students' Learning Outcomes Using Problem-Based Virtual Lab and Monopoly on Reaction Rates

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Abstract: *Learning outcomes constitute a fundamental metric in assessing the effectiveness of the educational process, as they encapsulate students' comprehension, mastery, and practical application of the knowledge and skills imparted during instruction. Within the educational framework, these outcomes function not only as indicators of the efficacy of pedagogical approaches and instructional media but also as essential references for the continuous evaluation and enhancement of teaching quality. This research seeks to examine the learning outcomes of students who were instructed using Virtual Lab and Reaction Rates Monopoly media, both implemented through a Problem-Based Learning (PBL) model. The participants in this study were students from classes XI Bio I and XI Bio II at SMAN 18 Medan, selected through purposive sampling techniques. Data analysis was conducted using a one-tailed t-test at a significance threshold of α = 0.05. The findings revealed that: (1) the mean learning score of students engaged with the problem-based Virtual Lab was 80.22, whereas those using the problem-based Reaction Rate Monopoly media achieved an average score of 70.00; and (2) students exposed to the problem-based Virtual Lab media attained significantly higher learning outcomes compared to their counterparts who used the problem-based Reaction Rates Monopoly media.*

Keywords: *virtual lab; monopoly learning media; problem-based; reaction rates*

INTRODUCTION

Education is a planned effort in the guidance and learning process for individuals to develop and grow into independent, responsible, creative, knowledgeable, healthy, and noble individuals, both physically and spiritually. Humans with noble morals and high morals are highly demanded to be formed and developed. The Indonesian nation not only exudes the importance of education, but also demonstrates how the Indonesian nation is able to realize the concept of education through sustainable and equitable development, training, and empowerment of Indonesian human resources (Inanna, 2018).

According to the Learning Curve Pearson data, a global education ranking institution reported that Indonesia ranked last in terms of education quality worldwide. In 2015, Indonesia remained among the ten countries with the lowest education quality, as indicated by the Global School Ranking. This demonstrates that the quality of education in Indonesia is still considered low (Muliaman & Mellyzar, 2020). Education is one of the main factors in preparing the younger generation to face an increasingly competitive era.

Therefore, educational institutions must address various issues, whether local, national, or rapidly changing global challenges. One effort to achieve these educational goals is by improving the quality of education Good educational quality largely depends on the learning process undertaken by students as learners. Quality education can be seen from the learning outcomes achieved by students. Learning outcomes are considered successful when students experience development and improvement in behaviors as expected in the formulation of learning objectives. This is evidenced and demonstrated through the evaluation scores given by teachers based on tests or exams taken by the students (Baidah et al., 2024; Yandi et al., 2023).

During the learning process, if a student realizes that they have made progress and improvement in their learning outcomes, they will be more motivated to study harder to further enhance their results. According to Benjamin Bloom, student learning outcomes are divided into three domains: 1) the cognitive domain, which relates to intellectual learning outcomes (knowledge); 2) the affective domain, which relates to attitudes; and 3) the psychomotor domain, which relates to skills and the ability to perform actions. Among these three domains of learning outcomes, the cognitive domain is the main focus for teachers, students, and parents to determine whether a student has improved after the learning process. Therefore, this study focuses only on the cognitive domain (knowledge) of the students (Purwandari & Wahyuningtyas, 2017)

One of the subjects in the 2013 curriculum that requires students to be active in the learning process is chemistry. Chemistry is a complex subject, full of concepts and calculations, which can cause students to become reluctant during the chemistry learning process (Silaban et al., 2021).

In the study of reaction rates, theoretical understanding alone is insufficient. Virtual laboratories have several advantages. These advantages include the ability to explain abstract concepts that cannot be explained verbally. Virtual laboratories can be a place to conduct experiments that cannot be done in conventional laboratories (Sumargo & Yuanita, 2014).

Many concepts in chemistry are abstract and complex, so to overcome this, the concepts need to be demonstrated in a more concrete form, for example through experiments or specific media. Therefore, virtual and real lab media can support the practical process in this learning process. They can be used for laboratory simulations on chemistry materials, allowing educators to create their own laboratory simulations (Sianturi & Panggabean, 2019).

Overall, reaction rate experiments not only deepen academic understanding but also cultivate practical skills essential for students to face real-world challenges in science and technology sectors. Therefore, teachers should plan lessons by selecting appropriate models, approaches, strategies, and methods aligned with the characteristics of the subject matter to create more enjoyable and meaningful learning experiences (Sundari et al., 2017).

A learning model refers to a systematic framework or approach used to design, organize, and manage the learning process. Each model has distinct characteristics and methods to achieve specific learning objectives. Problem-Based Learning (PBL) is a model that presents students with authentic and meaningful problem situations as the basis for investigation and exploration. Problem-Based Learning (PBL) is a learning model that encourages students to think critically about problems that arise during the learning process and enables them to solve these problems either in groups or individually (Dalimunthe & Ginting, 2022). PBL is a learning model that involves students in solving real-world problems using scientific methods, enabling them to gain knowledge and develop problem-solving skills. PBL enhances students' ability to identify problems, establish cause-and-effect relationships, and apply relevant concepts. This makes learning more enjoyable and meaningful (Ratna Sari et al., 2023). PBL has several advantages, including: 1)

Challenging students' abilities and providing satisfaction in discovering new knowledge, 2) Increasing student engagement in learning activities, 3) Helping students transfer their knowledge to solve real-life problems, and 4) Stimulating the development of students' thinking skills for effective problem-solving. PBL is an innovative learning model that fosters active learning, encouraging students to think critically about social issues they encounter. When combined with interactive media, the learning experience becomes more enjoyable, ensuring the achievement of learning objectives (Septiani Ari Pertiwi & Dibia, 2018).

An innovative learning medium that enhances student engagement is educational games. Educational games are interactive tools that incorporate educational elements to facilitate enjoyable and effective learning. Learning while playing promotes active participation.

One example of an educational game that offers engaging and enjoyable learning is Monopoly. Monopoly is a popular game among students due to its simplicity and fun nature. Using Monopoly as a learning medium can enhance students' memory retention, encourage them to express their opinions, and reinforce their understanding of concepts. Showed that learning using Monopoly games was more effective than conventional teaching methods (Ramadhani et al., 2016).

Monopoly games provide several benefits for increasing student interest in chemistry learning. Students actively engage and compete to win the game, fostering a spirit of competition. Monopoly also enhances students' memory retention in understanding chemistry concepts (Vikagustanti et al., 2014).

However, Monopoly games have limitations, including the time-consuming setup process and the requirement for students to divide into groups and distribute game materials. Additionally, Monopoly games are typically designed for teaching one specific concept at a time (Susanto et al., 2012). In the context of reaction rate learning, virtual labs play a significant role in increasing student interest and engagement. Virtual labs offer accessible, interactive, and visually immersive experiences, allowing students to conduct simulations and observe reaction rate phenomena. Realistic graphics, animations, and simulations help students better understand key concepts (Hikmah et al., 2017).

This study aims to analyze the learning outcomes of students who were taught using Virtual Lab and Reaction Rate Monopoly learning media, along with the Problem-Based Learning (PBL) model. The use of Virtual Lab and Reaction Rate Monopoly media serves as an alternative for enabling students to conduct virtual experiments and helps increase student engagement through game-based learning media, also known as edugames. Furthermore, the integration of the PBL model enhances students' active involvement in solving problems presented during the learning process.

LITERATURE REVIEW

Problem-Based Learning Model

The Problem-Based Learning (PBL) model is a learning model that begins with explaining the learning objectives and encouraging students to engage in problem-solving activities. These problems are then discussed by the students, followed by a presentation, and at the end of the activity, the teacher helps students reflect on the learning material. Teachers should emphasize the key topics when delivering lessons to facilitate students' understanding. In this context, the use of learning media is essential to capture students' interest and support their comprehension, for example, using visual aids such as images (Putri & Muhtadi, 2018).

Based Learning's problem learning model is learning that focuses on students as self-learners towards authentic or relevant problems that will be solved by using all the knowledge they have or from other sources. The implementation of problem base learning (PBL) models using concrete media can be an effort to improve mathematics learning outcomes. This is because the Problem Baseline Learning (PBL) model raises problems as an initial step in collecting and integrating new knowledge .Learning media is useful for facilitating students' understanding in the learning process. Learning Media as a tool in realizing the success of the teaching and learning process seems to have a big contribution to the teacher's victory in teaching. Apart from creating a happy atmosphere that is received by students, learning media also makes it easy for teachers to convey material and easy for students to receive it as a return for the process. The best use of learning media is to identify the form of teaching and learning activities that will be carried out so that appropriate learning media (Tambunan et al., 2024).

The Problem-Based Learning (PBL) model has several advantages compared to other learning models. Some of the strengths of the PBL model include (Sulastry et al., 2023) :

1. Students become accustomed to facing and solving problems, and they are constantly challenged to resolve the issues they encounter—not only academic problems but also those they face in everyday life.
2. This model fosters social solidarity among students by encouraging them to engage in discussions with their group members as well as with classmates.
3. It also enhances students' ability to interact with one another.
4. Furthermore, students may solve problems through experimentation, which helps them become familiar with applying experimental methods to problem-solving situations.

However, the PBL model also has some limitations:

1. It cannot be applied to all subjects. In some areas, teachers need to play an active role in delivering the material. This model is more suitable for subjects that require specific problem-solving skills.
2. Classrooms often have high levels of diversity among students, making it difficult to evenly divide tasks or responsibilities.

Learning Media

Media is all forms of intermediaries used by people to disseminate ideas, so that the idea reaches the recipient and provides limitations. In essence, media is a means called a channel, because in essence, media has expanded and extended human capabilities to feel, hear, and see within certain distance and time limits. Now, with the help of media, these limits have almost become non-existent. In the development and implementation of digital learning media, many aspects can be proposed as reasons to support education in relation to improving the quality of Indonesian national education. Digital learning media is capable and can be fought for to become the main facilitator for equalizing education in the archipelago, because by utilizing technology that relies on distance learning capabilities, it cannot be separated from space, distance, and time (Batlawi & Hamid, 2022; Sukaryanti et al., 2021).

With the advancement of information and communication technology, teachers must adapt their instructional methods to keep pace with these developments. They should be able to utilize engaging and enjoyable learning media that align with students' learning needs, so that students can more easily absorb the lessons delivered by the teacher (Nurrita, 2018).

Monopoly Learning Media

Various innovative learning media have been designed with different approaches to make the learning process more engaging and enjoyable for students. One example is the development of Monopoly-based educational media called "Moliaran" (Monopoly Learning). This type of game-based learning media allows students to learn while playing, making the learning process enjoyable, boosting their enthusiasm, simplifying comprehension, fostering creativity and active participation, and making learning more meaningful (Ardhani et al., 2021).

Virtual Lab Learning Media

Virtual laboratories have advantages in terms of practicality, such as being accessible anytime and anywhere. Because of the advantages and disadvantages of conventional and virtual laboratories, several literature studies have been conducted on the influence of virtual laboratories in science teaching, but most of them cover other disciplines, such as physics, chemistry, and engineering. A virtual laboratory is a computer program that can be used to support practical activities by providing simulations of practical activities similar to those in a real laboratory. Virtual laboratories can make things easier for students and are also expected to improve their scientific literacy skills Virtual laboratories can provide interactive simulations that allow students to observe and participate directly in experiments, thereby strengthening their understanding of scientific concepts (Agushesa & Prastiwi, 2024; Saleh et al., 2024).

Learning Outcomes

Learning is a gradual, directed change in student behavior through a planned and gradual process, so that at the end of the learning process, students will have the abilities or skills targeted by the teaching and learning system. Learning is a process characterized by changes in a person. Changes are the result of this process and can be demonstrated in various forms, including changes in knowledge, understanding, attitudes, and behavior. Skills, abilities, habits, and understanding are other aspects of a person's learning, and these changes are relatively permanent. Based on the description above, it can be concluded that learning is essentially characterized by: (1) changes in behavior, (2) acquired through experience, (3) relatively permanent results, and (4) changes related to physical and mental aspects (Daud, 2020).

Learning outcomes are not solely reflected in grades or products but also in the processes and attitudes exhibited by students during learning. For example, students often lack enthusiasm in reading and understanding the material, are hesitant to ask questions, and are reluctant to express their opinions. Additionally, responsibility and teamwork skills are often underdeveloped. During group discussions, only a few students actively participate, while others tend to engage in unrelated conversations. Moreover, students frequently submit assignments carelessly and miss deadlines, indicating a lack of discipline and thoroughness.

When teachers conduct evaluations or daily tests, many students resort to copying from their peers, which demonstrates low self-confidence. To address these issues, implementing effective learning models like PBL, integrating innovative learning media, and fostering student engagement through interactive activities can significantly improve learning outcomes and enhance student confidence (Paradina et al., 2019).

Aspects of Learning Outcomes

The cognitive domain encompasses mental (brain) activity. According to Bloom, all efforts involving brain activity fall within the cognitive domain. The cognitive domain relates to thinking skills, including memorization, understanding, application, analysis, synthesis, and evaluation. Learning outcomes in the affective domain are measured in four categories: (1) active, (2) responsible, (3) disciplined, and (4) hard work. The active category includes aspects of cooperation and tolerance. The responsible category includes aspects of self-confidence and politeness. The discipline category includes aspects of curiosity and communication. The hard work category includes logical and creative thinking (Feby & Sudarmin, 2017).

METHODS

This research is an experimental study conducted on two samples taken from several populations. The population in this study consisted of all XI students at SMAN 18 Medan. The sample consisted of two classes, each with 36 students. The first sample, referred to as Experimental Class I, received treatment using virtual lab learning media with a problem-based learning model. The second sample, referred to as Experimental Class II, received treatment using reaction rate monopoly learning media with a problem-based learning model.

The instrument used to collect data in this study was a test instrument consisting of a pretest and posttest. The test comprised 40 multiple-choice questions. Prior to use, the test instrument was analyzed for validity, difficulty level, discrimination index, reliability, and distractor effectiveness. The data obtained from the research were then processed and analyzed using SPSS software to address the research questions, objectives, and hypotheses. The data analysis techniques used included descriptive and inferential statistical analysis. Descriptive analysis was employed to describe the data, including the minimum and maximum scores, mean, and standard deviation.

Inferential statistical analysis was used to test the research hypotheses using a one-tailed t-test at a significance level of 0.05. Before hypothesis testing, prerequisite tests were conducted on the data using normality and homogeneity tests.

RESULT AND DISCUSSION

The data in this study consists of students' learning outcomes measured using a test instrument through a pre-test (before treatment) and a post-test (after treatment).

Table 1. Description of research Data

Average ±STDV	Virtual Lab		Monopoly	
	Pretest	Postest	Pretest	Postest
High	33.07±6.04	79.2±7.88	34.4±4.22	35.2±7.68
Low	18.95±4.54	81.71±11.4	16.48±5.21	49.71±9,25

Based on Table 1, it is shown that the average pre-test score of the low virtual lab group is higher than the low monopoly group, with scores of 18.95±454 compared to 16.48±5.21. On the other hand, the average pre-test score of the high virtual lab group is lower than the high monopoly group, with scores of 33.07±6.04 compared to 34.4±4.22. Similarly, both the low and high post-test scores of the virtual lab group are higher than those of the monopoly group, with scores of 81.71±11.4 compared to 49.71±9.25

Normality Test

The normality test is used to determine whether the data is normally distributed, indicating that the samples come from the same population. The normality test for students' learning outcome improvement was conducted using SPSS 26.0 for Windows with a significance level (α) of 0.05.

Table 2. Normality Test

	Group	Data	*Klmgrv Sminov*	Description
			Sig.	
Outcame Learning	Eks I	Postest	0.200	Normal
	Eks II	Postest	0.137	Normal

Based on the data in the table above, the significance (sig.) values for students' learning outcomes in both Experimental Class I and Experimental Class II are greater than α (0.05). This indicates that the students' learning outcomes using problem-based virtual lab learning media and reaction rate monopoly learning media are normally distributed.

Homogeneity Test

The homogeneity test is conducted to determine whether the samples come from homogeneous data. This test was conducted using Levene's Test with the help of SPSS 26.0 for Windows with a significance level (α) of 0.05.

Table 3. Homogeneity Test

			Description
		Sig.	
Learning Outcome	Mean	0.188	Homogeneous
	Median	0.188	Homogeneous

Based on the table above, the obtained significance value is 0.188 > α = (0.05), indicating that the learning outcomes of experimental class I and experimental class II are homogeneous, or in other words, the data is normally distributed

Hipothesis Testing

Following confirmation that the data meet the assumptions of normality and homogeneity, hypothesis testing was conducted. This procedure employed the Independent Sample Test using SPSS version 26.0 for Windows, with a predetermined significance level (α) of 0.05.

Table 4. Hipothesis Testing

	Sig.	t	Description
Outcame Learning	0.00	4.685	Significant

Referring to the data presented, the significance value associated with the learning outcomes of Experimental Class I utilizing problem-based virtual lab media and Experimental Class II employing problem-based reaction rate Monopoly media—was 0.00, which is less than α (0.05). This indicates a statistically significant difference. Consequently, it can be inferred that students who were taught using problem-based virtual lab media achieved higher learning outcomes compared to those instructed with problem-based reaction rate Monopoly media.

DISCUSSION

Based on the prerequisite assessments, specifically the normality and homogeneity tests, the findings revealed that the normality test results exceeded the threshold significance level of 0.05. In the posttest data, the significance value for experimental class I was 0.200, while for experimental class II it was 0.137. Given that both 0.200 and 0.137 are greater than 0.05, it can be inferred that the distribution of learning outcomes in both experimental groups adheres to the assumption of normality.

In addition, the homogeneity test conducted on the posttest scores yielded a significance value of 0.188, which is also above the 0.05 threshold. This result indicates that the variances among the groups are statistically equal, confirming the assumption of homogeneity. Following these tests, a hypothesis test was performed using a one-tailed Independent Samples T-Test via SPSS version 26.0 for Windows at a 5% level of significance. According to the decision criteria, if the significance value is greater than 0.05, the null hypothesis (H_0) is accepted, and the alternative hypothesis (H_a) is rejected. However, the test produced a significance value of 0.000, which is less than 0.05, leading to the acceptance of H_a and the rejection of H_0 in this study.

Which demonstrated that students who utilized virtual laboratory media achieved significantly higher learning outcomes than those who used audiovisual media. In line with that, the present study also supports the effectiveness of virtual lab media over monopoly-based learning tools, as they allow students to directly observe the movement and transformation of substances influenced by reaction rate factors. Conversely, students using monopoly-based media are not afforded the same direct observation opportunities. Nevertheless, there was still a noticeable improvement in the learning outcomes of students in the monopoly media group

This result aligns with the study by (RIFAI, 2019), as referenced in the background section, which demonstrated that students who utilized virtual laboratory media achieved significantly higher learning outcomes than those who used audiovisual media. In line with that, the present study also supports the effectiveness of virtual lab media over monopoly-based learning tools, as they allow students to directly observe the movement and transformation of substances influenced by reaction rate factors. Conversely, students using monopoly-based media are not afforded the same direct observation opportunities. Nevertheless, there was still a noticeable improvement in the learning outcomes of students in the monopoly media group.

Consequently, the researcher concludes that monopoly-based media can also serve as an effective educational tool for enhancing student engagement and interest in the learning process, thereby helping to mitigate boredom. Moreover, based on responses gathered through the student feedback questionnaire regarding the instructional media, students reported that the media played a crucial role in the learning experience by fostering greater interest and facilitating deeper understanding of the subject matter during class sessions.

CONCLUSION

The conclusion is that the learning outcomes of students taught using Virtual Lab learning media with the Problem-Based Learning model are higher than those of students taught using Reaction Rate Monopoly media with the same model. This is supported by both the cognitive domain learning outcome analysis through grouping and hypothesis testing, where the final learning outcome of students using problem-based Virtual Lab media is 80.22, while that of students using problem-based Reaction Rate Monopoly media is 70.00.

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