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The Effect of Problem-Based Learning Model Accompanied by the QuizWhizzer Game on Critical Thinking Skills and Physics Learning Outcomes of Vocational Students

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Abstract

Physics learning is learning that influences students' thinking skills so that students can be skilled in the cognitive and psychomotor fields and support students to think systematically, creatively, and objectively. But in fact, the implementation of learning that occurs is not contextual because the way teachers teach in class is still boring and less varied, so student involvement in the learning process in class becomes less active, both asking and answering questions. This study aims to determine the effect of using a problem-based learning model accompanied by a QuizWhizzer game on vocational students' critical thinking skills and physics learning outcomes in Jember Regency. This study used a quantitative approach, specifically a true experimental design of a posttest-only control group. The study population consisted of class X students at SMK Negeri 1 Jember, with the sample comprising two classes selected from all classes at SMK Negeri 1 Jember. Data analysis of students' critical thinking skills using the Mann-Whitney U Test resulted in a significance value (2-tailed) of 0.038 < 0.05, which leads to the rejection of H_0 and acceptance of H_a. Data analysis of students' physics learning outcomes using the Mann-Whitney U Test and hypothesis testing results resulted in a significance value (2-tailed) of 0.023 < 0.05, which leads to the rejection of H_0 and acceptance of H_a. These findings indicate a significant effect of applying a problem-based learning model assisted by QuizWhizzer on students' critical thinking skills and physics learning outcomes, especially on energy and its changes. With this research, teachers can design more effective learning models to support critical thinking skills and optimal student learning outcomes in physics learning accompanied by learning media by analysing student needs, selecting learning models, developing learning media, planning learning activities, and implementing them.

Keywords: Critical thinking skills; physics learning outcomes; problem-based learning model; quizwhizzer media

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INTRODUCTION

The advancement of science and technology in the era of globalisation is unavoidable. Facing these advancements, education is an important foundation that requires preparation to equip most students, as technology users, to cope with the diverse challenges of the 21st century effectively. The development of this technology certainly provides a new paradigm and perspective on learning media (Indriani et al., 2020; Mardhiyah et al., 2021). The involvement of technology in learning activities can certainly make teaching and learning activities in the classroom more effective and efficient as one of the supporting tools for the learning process (Puspitasari, 2019; Suyuti et al., 2023).

Physics is one of the branches of science that studies related natural symptoms and phenomena along with the interactions that occur in everyday life. In addition to natural phenomena, physics provides good lessons for humans to live in harmony with natural laws (Mayanti et al., 2022). The purpose of learning physics is to influence students' thinking skills so that they can be skilled in the cognitive and psychomotor fields and support students to think systematically, creatively, and objectively. A good understanding of concepts can certainly be the basis of good problem-solving skills (Yana et al., 2019; Yusuf et al., 2020). However, the learning objectives, in fact, still cannot be achieved optimally. This is because the way teachers teach in class still needs to be more varied and varied. As a result, student involvement in the learning process is less active, as well as asking and answering questions. Students need more student involvement in learning to pay more attention to physics subjects. The implementation of learning that is not contextualised can cause students to be incompetent in linking the understanding of the science they learn with phenomena that occur in real life so students' physics learning outcomes are low. Based on this description, the teacher must be skilled in sorting out the learning model using the appropriate approach.

The characteristics of a good learning model, according to Yusuf & Syurgawi (2020), are being able to achieve learning objectives, student participation being carried out actively and creatively in learning, the percentage of student activities being more dominant than the teacher there is an appropriate selection of tools, games, and learning materials. Teachers act as facilitators, motivators, and gamers in the learning process. Other characteristics of an effective learning model include having clear and measurable learning objectives, encouraging active student involvement in the learning process, providing opportunities for independent learning, utilising various methods and learning resources, creating a positive and supportive learning environment, providing constructive and timely feedback, evaluating student progress regularly, being flexible and adaptable to student needs, paying attention to individual student differences, and being supported by previous research and evidence (Ann et al., 2003; Haviz, 2004). This research by Aprilia & Yoyo (2020) investigated the potential of implementing various learning models in the physics curriculum to enhance students' learning experience and improve academic achievement in physics. In addition, Mayanti et al. (2022) explained that teachers can use learning models to achieve educational goals in every lesson.

The results of interviews conducted with two physics teachers at SMK Negeri 1 Jember show that there are still many problems experienced during the physics learning process in the classroom, such as considering physics lessons as difficult to understand, boring, and even less interesting to learn. In addition, the use of learning models is applied; the teacher is

more dominant in the learning process and tends to be informative, so active student involvement in the learning process still needs to be improved. As a result, the atmosphere in the classroom tends to be passive, and student activity is low.

At its core, effective learning is a teaching and learning activity that is not only focused on results but also related to the learning process in order to provide a good and precise understanding. Effective learning can also train and foster democratic attitudes in students. The effectiveness of learning becomes very important in achieving the quality standards of education, which the achievement of learning objectives can usually measure. Thus, effective learning is very important. It is undeniable that if there is boredom in the learning process, it is none other than usually due to fatigue in physical, mental, emotional, and mental aspects. As a result, students need to be more productive in their learning activities. If this is allowed to continue, it will result in poor individual psychological conditions.

Based on the Process Standards of Government Regulation No. 22/2016, there are various recommendations regarding learning models, including problem-based learning (PBL), inquiry, guided discovery, and project-based learning (PjBL). In addition, Maslahah et al. (2021) showed that the learning outcomes of students who applied the PBL model showed superior achievement compared to the discovery learning model. The results of Widiyanto's (2019) study determined that academic achievement, as measured by student learning outcomes, was significantly greater when using the PBL model, with a mean score of 83.68 compared to the guided inquiry model, which had a mean score of 78.97. Learning outcomes in the field of education are very important. This happens because student learning outcomes can be a benchmark for measuring how much ability students have, both in cognitive, affective and psychomotor aspects. Of course, to achieve good learning outcomes, a learning model needs from teacher to student-centred learning. Given the aforementioned challenges relating to student learning outcomes, particularly in physics, the need to develop a new pedagogical paradigm that effectively addresses these issues becomes apparent.

Such a model should seek to improve academic achievement and simultaneously foster critical thinking skills that are critical to navigating the complexities inherent in the learning process. Critical thinking skills are regular reasoning skills, systematic skills in assessing, solving problems, drawing decisions, giving confidence, analysing assumptions and performing scientific searches. These critical thinking skills encompass a diverse spectrum of cognitive activities, including, but not limited to, the analysis, synthesis, and evaluation of newly acquired knowledge, in addition to their creative application in the face of evolving challenges that are characteristic of the contemporary era of globalisation (Darmaji et al., 2022; Sutikno, 2019). In research conducted by Zakiyah et al. (2023), the evaluation analysis of students' critical thinking skills showed a significant improvement from the pre-action phase to cycle I and then to cycle II through the problem-based learning model. Rahardhian (2022) also showed that critical thinking skills are a skill that cannot be replaced by Artificial Intelligence (AI) or other types of robots because a person's critical thinking skills can be selected, integrated, and utilised according to their needs. The research findings show that among various learning models, the problem-based learning model has a significant influence on students' critical thinking skills and learning outcomes.

PBL is a learning model that emphasises selecting specific problems so students can learn scientific concepts and methods for solving them. The goal is to help students deal with real-life situations (Rahmadani, 2019; Ardianti et al., 2022). The PBL paradigm utilises authentic, real-world scenarios to acquire knowledge (Ennis, 2011; Haviz, 2004; Rahayu, 2014). Students develop critical thinking and problem-solving acumen by actively engaging in these challenges. The characteristics of the PBL model include:

1) The learning begins with the presentation of a problem.
2) Students are actively grouped to formulate problems
3) Students study and look for their material related to the problem to find the right solution to the problem (Amir, 2016; Suardana, 2019).

Piaget suggests that students can be actively involved in obtaining information and building their knowledge. The knowledge referred to here is dynamic so when students are given a new problem, students are forced to be able to build and modify the knowledge that students have experienced before. In Jean Piaget's perspective, cognitive development is seen as the result of synergy between brain maturation, the nervous system, and experiences that facilitate adaptation to the environment. This underscores the importance of the complex interaction between innate biological factors and environmental factors in shaping individual thinking abilities. The context of the PBL model, in this case, can be faced with a problem that challenges students to find a solution to a given problem (Ardianti et al., 2022; Nasir, 2022).

This opinion is supported by research conducted by Datreni (2022), which states that PBL is very suitable for learning characteristics to develop students' thinking patterns, especially in problem-solving. This research shows that the PBL model presents a viable alternative approach to conventional teaching, encouraging active student involvement in the learning process. This active participation is hypothesised to improve students' critical thinking skills and better learning outcomes. In addition, implementing PBL can be strategically complemented by incorporating learning games within the classroom environment. The presence of games as a supporting element in the learning process can enhance students' knowledge and advance their thinking skills. Therefore, educators can combine learning models with educational games to enhance the learning experience in the classroom. Figure 1 follows a display from QuizWhizzer media.

Figure 1 Media QuizWhizzer

One of the learning games that can be used in this globalisation era is Quizwhizzer. Quizwhizzer is one of the Android-based educational game applications that can be used to convey material in a more interesting and fun way in the learning process in class (Nasir, 2022; Oktavian et al., 2023). This is because QuizWhizzer media has advantages that can support the learning process in the classroom, including 1) making it easier for teachers to create innovative questions based on information technology, 2) selecting the random mode in doing quizzes can minimise cheating as well as train students' honesty, and 3) making it easier for teachers in the assessment process, because if students answer the quiz questions incorrectly, the correct answer will appear along with a discussion as an independent correlation for students (Septiani & Santi, 2022; Susanto & Ismaya, 2022). In addition, according to Yusuf & Syurgawi (2020), quizwhizzer games can be used as learning evaluation games in the classroom more effectively and efficiently.

Based on this description, researchers need to explore further the PBL model combined with the application of QuizWhizzer games to improve critical thinking skills and student physics learning outcomes. This study differs from previous studies because it combines the QuizWhizzer game with the PBL model. This is because the use of QuizWhizzer media so far is still widely combined with the team games tournament (TGT) learning model and the discovery learning model and is still very rare if combined with a problem-based learning model (Faijah et al., 2022; Sumandya & Gita Saraswandewi, 2023). This new integration requires this study to be entitled "The Effect of Implementing Problem-Based Learning Model Assisted by QuizWhizzer Game on Critical Thinking Skills and Physics Learning Outcomes of Vocational Students in Jember Regency." The main objective of this study is to evaluate the effect of applying the PBL model assisted by the QuizWhizzer game on critical thinking skills and physics learning outcomes of vocational students in Jember Regency.

METHOD

This research is included in quantitative research with a research design in the form of a posttest-only control group design formed by two groups, namely the experimental and control groups. According to Sharma (2017), this design can be helpful when it is not possible to pretest the subjects, for example, to study the effect of an educational intervention related to urinary incontinence on the subsequent help-seeking behaviour of older adults. This research design used a two-group pretest-posttest experimental approach involving experimental and control groups. The existence of these two groups facilitates a robust comparison between the effects of a given treatment and the absence of such treatment. Notably, the control group received no treatment and followed the conventional learning model usually used by physics instructors. In contrast, the experimental group benefited from implementing a problem-based learning model supported by the Quizwhizzer media. According to Javali & Shankarling (2024), an ample array of resources is available to researchers, from which they may derive potential research problems or develop an awareness of existing issues.

The implementation of the study begins with making a research hypothesis and then determining the research hypothesis, which consists of independent and dependent variables. Next, each sample group received interventions and underwent a post-test to assess their critical thinking ability and physics learning outcomes. Finally, using normality tests and hypothesis testing

procedures, this study investigated the hypothesised effects of implementing a problem-based learning model supplemented with quiz games on students' critical thinking skills and physics learning achievement. Classifies aspects of critical thinking indicators into five, namely: (1) giving simple explanations (elementary clarification), including a focus on questions, analysing arguments, and asking and answering questions that require explanation or challenge; (2) developing basic skills (basic support), including consideration of the credibility of sources and observations; (3) Inference, including: compiling and considering deduction, compiling and considering induction, and compiling decisions and considering the results; (4) Advanced clarification, including identification of terms and definitions, and identification of assumptions; and (5) Strategies and tactics, including determining actions and interactions with others (Ann et al., 2003; Ennis, 1985; Haviz, 2004). To achieve these objectives, this study used normality tests and hypothesis testing. A normality test was conducted to determine whether the data obtained were normally distributed. If the critical thinking skills data is normally distributed, then the analysis is continued by using the parametric test, namely the Independent Sample T-Test. Conversely, if the data is not normally distributed, a non-parametric test is used, namely the Mann-Whitney U Test. The basis for making normality test decisions is that the data is normally distributed if the Sig value is used. (2-tailed) > 005, and the data is not normally distributed if the Sig value. (2-tailed) < 0.05.

There are various activities that students can do when using QuizWhizzer media in the PBL model, namely: (1) students can work together in teams to answer questions related to a problem through quizzes designed by the teacher; (2) students can compete among friends in answering quizzes to get the maximum score; (3) after the quiz is over, students and teachers can discuss the correct answers and explain some concepts that are still confused. The relationship between critical thinking skills and learning outcomes with QuizWhizzer media in the PBL model lies in how this media can be used to stimulate students' critical thinking skills by designing challenging questions that require critical thinking. Consistent with the research of Faijah et al. (2022), the use of QuizWhizzer media in learning effectively improves students' understanding of concepts so that teachers can help students develop critical thinking skills and student learning outcomes by analysing the information provided, evaluating answers according to the problem at hand, and making the right decision. Thus, QuizWhizzer can be an effective medium to support student's development of critical thinking skills and physics learning outcomes.

RESULT AND DISCUSSION

This study examines the effectiveness of incorporating PBL pedagogy, facilitated by the Quizwhizzer interactive quiz platform, in the development of critical thinking skills and academic achievement in physics among vocational program students in Jember District, East Java, Indonesia, conducted at SMK Negeri 1 Jember, a public vocational high school in the first semester of the 2023/2024 academic year. The media used in this study was quiz whizzes media, which required approval of media feasibility using expert judgment from the main supervisor and member supervisors. The results of media expert judgment that have been carried out state that the media used are suitable for use in the learning process in the classroom on energy and its changes with some improvements, namely not only using multiple choice questions but

also needing to use essay questions on the media used and needing to add information to the images used in the questions to make it clearer. The first stage of this study was to conduct interviews related to physics learning problems with two physics teachers at SMK Negeri 1 Jember. Interviews are one of the data collection techniques used to reveal an individual's experience and how they understand the experience. Using this interview technique, the researcher can obtain a detailed response from the source (Alamri, 2019; Dursun, 2023).

A thematic analysis of interviews with two physics teachers reveals ongoing challenges in the classroom learning environment. These challenges centre on students' perceptions of physics as a complicated and uninteresting subject, thus driving a decline in student engagement. In addition, the observed learning model shows a teacher-centred approach, which is characterised by informative delivery and limited opportunities for active student participation. The atmosphere in the classroom tends to be passive, and student activity is still relatively low. The lack of enthusiasm and participation of students in the learning process in the classroom certainly evidences this problem. This condition certainly makes students need clarification about the physics subject matter explained by the teacher so that the results of physics subject exams, both daily tests, Midterm Exams and Final School Exams, most students get poor grades.

The next step is to determine the control class and the experimental class. The population in this study is class X, which is then subjected to a homogeneity test to ensure that the population tested is homogeneous. The Midterm Examination value in physics subjects is used as data to be tested for homogeneity. The homogeneity test technique in this study uses the Anova test found in IBM SPSS 23. The following is Table 1 data on the homogeneity test results.

Table 1 Homogeneity test results

Test of Homogeneity of Variances

Physics test results

Levene Statistic	df1	df2	Sig.	Results
.784	2	105	.459	The results of the homogeneity test in the table test of homogeneity of variances obtained data that shows the data is homogeneous.

Based on Table 1, it can be seen that the results of the homogeneity test in the test of homogeneity of variances table obtained data that shows the data is homogeneous. This study examines the effect of a PBL model equipped with Quizwhizzer media on the physics learning outcomes of DKV X class students. The homogeneity test conducted resulted in a significance value (Sig.) of 0.459, which confirms the homogeneity of the data between the two classes (Sig. > 0.05). Based on these results, class X DKV 2 (n = 36) was designated as the control group, while class X DKV 3 (n = 36) as the experimental group. Research activities were adjusted to the existing physics lesson schedule for both groups.

This research was conducted for two weeks with three face-to-face meetings. The first and second meetings were used to treat each class. The control class used the lecture model that the teacher used before at school, while the experimental class used a problem-based learning model assisted by quiz whizzes media. In the third meeting, a post-test was conducted in each class, both control and experimental classes, totalling 15 items

with ten multiple-choice questions and five essay questions.

Implementing the PBL model in the experimental group consisted of five learning stages. The first stage, called "problem orientation," involves introducing students to the core learning objectives and essential competencies related to the topic. In addition, this stage also incorporated motivational strategies to stimulate students' interest in exploring the concept of energy and its application in daily life. At this stage, the teacher divides students into several groups, gives questions in the quiz whizzes media, and solves them through the Learner Worksheet provided by the teacher to conduct discussions according to their respective groups. The following is a display of the QuizWhizzer media used in this study.

Figure 2 QuizWhizzer game display

At work time, the questions on QuizWhizzer media can be seen in Figure 3.

(a) (b)

Figure 3 (a) Display of multiple-choice questions and (b) Display of essay questions

There are various activities that students can do when using *QuizWhizzer* media in the PBL model, namely: (1) students can work together in a team to answer questions related to a problem through quizzes made by teachers; (2) students compete between friends in answering quizzes to get the maximum score; (3) after the quiz ends, students and teachers can have discussions related to the correct answers and explain some concepts that are still confused. The relationship between critical thinking skills and *QuizWhizzer* media in the PBL model lies in how this media can be used to stimulate students' critical thinking skills by designing challenging questions that require critical thinking. Worthy of the research of Faijah et al. (2022), the use of *QuizWhizzer* media in learning is effective in improving students' understanding of concepts so that teachers can help students develop critical thinking skills and analyse the information provided, evaluate answers according to existing problems, and make the right decisions. Thus, *QuizWhizzer* can be an effective medium for supporting the development of students' critical thinking skills.

The next stage is that the teacher investigates the group to solve some of the problems contained in the quiz whizzes media related to energy and its changes. Students are guided by the teacher so that they do not find it difficult to solve problems. The fourth stage is to develop and present the work by presenting the results of problem-solving carried out by students in front of the class. The designated group prepares the problem-solving results to be displayed in front of the class, and other groups listen and provide input related to the problems discussed. The last stage is to analyse and evaluate the results of problem-solving with students, assisted by the teacher, to reflect on and evaluate the problems that have been discussed. Furthermore, the teacher also confirms things related to the problems studied. In the control class, the treatment was carried out by applying a lecture learning model consisting of three stages: preparation, implementation, and closing.

The first objective of this study is to determine the effect of applying a problem-based learning model assisted by quiz whizzes media on the critical thinking skills of vocational high school students in the Jember Regency. Measurement of critical thinking skills is carried out on each aspect, namely determining problems and analysing arguments (basic clarification), making observations and analysing the results of observations (the bases for a decision), determining and generalising problem solutions (inference), identifying arguments and evaluating arguments obtained (advanced clarification), determining the relationship of existing concepts and determining appropriate actions (supposition and integration). Data on critical thinking skills was collected through a post-test administered to both the experimental and control groups. The post-test consisted of five questions to assess students' critical thinking abilities. The results are presented visually in Figure 4, which depicts each group's average critical thinking skill scores.

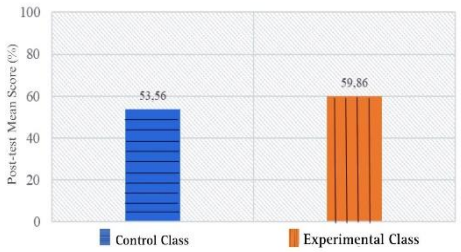

Figure 4 Graph of the percentage of the average value of critical thinking skills

The analysis in Figure 4 shows that the average value of post-test critical thinking skills in the experimental class that applied the problem-based learning model assisted by quiz whizzes media on energy and energy changes was higher than that in the control class that applied the learning model commonly used by teachers at school. The average percentage value obtained by the control class was 53.56, while the experimental class obtained an average percentage value of 59.86. Based on this, Table 1.3 below presents the normality test results using the Kolmogorov-Smirnov technique on critical thinking skills.

Tabel 2 Normality test on critical thinking skills

One-Sample Kolmogorov-Smirnov Test

		Control Classes	**Exsperimental Classes**	**Results**
N		36	36	Based on the Sig value. (2-tailed) < 0.05 indicates that the control class and
Normal Parameters[a,b]	Mean	53.56	59.86	

	Std. Deviation	11.433	12.138	experimental class are not normally distributed.
Most Extreme Differences	Absolute	.186	.166	
	Positive	.106	.079	
	Negative	-.186	-.166	
Test Statistic		.186	.166	
Asymp. Sig. (2-tailed)		.003[c]	.013[c]	

Data normality distribution analysis was performed using the Kolmogorov-Smirnov normal distribution test. The test results showed a Sig. (2-tailed) of 0.003 in the control group and 0.013 in the experimental group. Both values are smaller than 0.05, so it can be concluded that the data is not normally distributed. This decision is in accordance with the decision-making rules, which state that if Sig. (2-tailed) < 0.05, then the data is not normally distributed. Since the data were not normally distributed, the Mann-Whitney U non-parametric test was used to analyse the differences between the two groups. Table 3 presents the Mann-Whitney U test results for critical thinking skills.

Tabel 3 Non-parametric test Mann-Whitney U Test on critical thinking skills

Test Statistics

	Critical thinking skills	Results
Mann-Whitney U	465.000	This shows that H0 is rejected and Ha is accepted, which means that the application of the PBL model assisted by QuizWhizzer media significantly affects students' critical thinking skills on material energy and its changes.
Wilcoxon W	1131.000	
Z	-2.070	
Asymp. Sig. (2-tailed)	.038	

Statistical analysis using hypothesis testing shows a Sig. (2-tailed) of 0.038, which is smaller than the critical value of 0.05. This finding implies the rejection of the null hypothesis (H0) and accepting the alternative hypothesis (Ha). Thus, it can be concluded that applying a problem-based learning model assisted by the QuizWhizzer game significantly affects students' physics critical thinking skills on energy and its changes. This study's results align with the findings of Ahmad & Prasetyo (2023), who stated that critical thinking skills, in general, can improve students' analytical acumen and understanding of complex subject matter, such as photoelectricity. Additionally, research by Khaeruddin & Bancong (2022) states a significant increase in the N-gain score of students' critical thinking skills through a PhET simulation of 0.45 on Newton's Law material. Not only that, but the research conducted by Anggraeni et al. (2024) also stated that the percentage of the implementation of the learning process carried out using the Problem-Based Learning model has increased from the first cycle to the third cycle. The following is the data of indicators of students' critical thinking skills in the control and experimental classes, which can be seen in Table 4.

Table 4 Achievement of students' critical thinking skills indicators

Aspects of Critical Thinking Skills	**Percentage of Critical Thinking skills**	
	Control Classes	Experimental Classes
Basic Clarification	74.16	76.11
The Bases for a Decision	37.22	37.22
Inference	46.80	66.94
Advanced Clarification	60.27	49.02
Supposition and Integration	45.97	61.11
Average	53.56	59.86

Table 4 shows the results of the percentage of students' critical thinking skills indicators between the control class and the experimental class. In the control class and experimental class, the basic clarification aspect got the highest score, with an effect of 1.95%. This happens because this aspect is easier to understand than other critical thinking skills, which focus on understanding explicit and direct information. The evidence is that most students in this aspect can be able to answer the questions given correctly. The second aspect, namely the basis for a decision aspect, is the aspect with the lowest score compared to other critical thinking aspects, both in the control and experimental classes, with the same percentage. This means that there is no influence in this aspect. The evidence is that most students find it challenging to answer the questions given because this aspect is fairly complex and requires a deep understanding of the concepts and principles of critical thinking. In addition, students need more practice in developing this aspect.

The third aspect is inference, with an influence of 20.14%. This happens because, in this aspect, students are good enough at using various information that can help in problem-solving so that students can make the best alternative that can be used as a solution. Students are also accustomed to checking the answers given to minimise errors. This aspect includes questioning facts, making alternatives, and drawing conclusions. The fourth aspect is advanced clarification, which shows that the control class is much better than the experimental class. This happens because students have been unable to define forms and consider existing terms and are not accustomed to predicting things related to the subject matter. This aspect includes activities to identify terms and definitions of considerations as well as dimensions, as well as identify assumptions. The last aspect is supposition and integration, which influence 15.97%. This happens because students cannot critically consider doubtful reasons without letting personal assumptions influence their thinking. Most students also have yet to be able to integrate their critical thinking skills with other characters and skills in decision-making. This shows the need to develop critical thinking skills in the learning process. This aspect includes considering reasons and combining other skills and characters in decision-making.

The difference in students' critical thinking skills occurred due to differences in treatment between the experimental and control classes. The researcher gave treatment to the experimental class by applying a problem-based learning model assisted by quizwhizzer media, while the control class applied what the teacher usually applied at school. Using Quizwhizzer media in the experimental class can be useful as an interactive learning tool that helps teachers create a more interesting and less boring learning process. This is evidenced by the enthusiasm of students who are actively involved in the learning process, both in asking and answering questions given so that the learning runs smoothly. In addition, during the learning

process, students become more enthusiastic about learning because, for the students themselves, the learning is more interesting and fun with the use of Quizwhizzer media. The findings of this study are characterised by the acquisition of average scores on post-test questions of experimental classes that are better than control classes. This shows that applying problem-based learning models assisted by Quizwhizzer media positively impacts students' physics critical thinking skills on energy and its changes.

The second objective discussed in this study is to determine the effect of the application of a problem-based learning model assisted by quiz whizzes media on the physics learning outcomes of vocational students in Jember Regency. Indicators used in student physics learning outcomes are six indicators of cognitive learning outcomes, including remembering (emphasising student thinking skills), understanding (skills in understanding, explaining, and interpreting facts in other situations), application (skills in applying information that has been learned), analysis (efforts to sort information into parts with a clear arrangement), evaluation (skills to assess information that has been learned), and creating (skills to assemble everything into an innovation). Based on these findings, this study uses the cognitive domain in learning with six dimensions, namely memory (C1), understanding (C2), application (C3), analysis (C4), evaluation (C5), and creation (C6). A visual representation of the average percentage of physics learning outcomes is depicted in Figure 5.

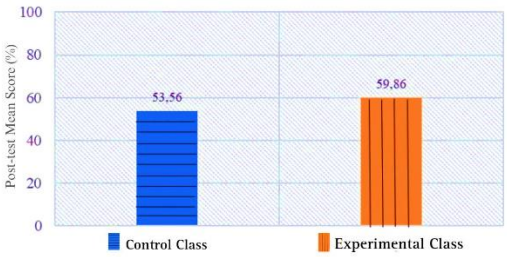

Figure 5 Graph of the percentage of the average value of physics learning outcomes

When viewed from Figure 5, it can be seen that students in the experimental group who used the problem-based learning model equipped with Quizwhizzer media in learning energy and its transformation obtained significantly higher scores on the post-test that measured physics learning outcomes compared to the control group who used the conventional learning model conducted by the teacher. The control group obtained an average score of 65.08%, while the experimental group achieved an average score of 69.97%. Based on these findings, Table 5 presents the normality test results conducted using the Kolmogorov-Smirnov technique to assess the normality of the students' physics learning outcomes data.

Table 5 Normality test on physics learning outcomes

One-Sample Kolmogorov-Smirnov Test			
		Control Classes	Experimental Classes
N		36	36
Normal Parameters[a,b]	Mean	61.11	68.06
	Std. Deviation	13.044	11.909
Most Extreme Differences	Absolute	.224	.232
	Positive	.137	.130
	Negative	-.224	-.232
Test Statistic		.224	.232
Asymp. Sig. (2-tailed)		.000[c]	.000[c]

Data normality distribution analysis was conducted using the Kolmogorov-Smirnov normal distribution test. The test results showed a Sig. (2-way) of 0.000 for both samples, namely the control and experimental groups. Based on the decision-making criteria, if Sig. (2-way) < 0.05, then the data is not normally distributed, then both samples are concluded not to be normally distributed. Therefore, the Mann-Whitney U non-parametric test was used to test the difference between the two groups. Table 6 presents the results of the Mann-Whitney U test to determine the difference in physics learning achievement of vocational students.

Table 6 Non-parametric test Mann-Whitney U test on physics learning outcomes

Test Statistics	
	Result Learning
Mann-Whitney U	444.500
Wilcoxon W	1110.500
Z	-2.368
Asymp. Sig. (2-tailed)	.018

Analyzing students' physics learning outcomes utilised the Mann-Whitney U non-parametric test to assess the hypothesis. The two-tailed test's statistical significance (Sig.) is 0.023, below the conventional alpha level of 0.05. This statistically significant result ($p < 0.05$) leads to the rejection of the null hypothesis (H_0) and acceptance of the alternative hypothesis (H_a). It indicates strong evidence for the significant impact of the implemented problem-based learning model, assisted by the Quizwhizzer game, on student achievement in energy and its transformations in physics. This is in line with the research of Wijayanto et al. (2020), who suggest that applying physics learning using a problem-based learning model with a STEM approach in the vector discussion subject can enhance student learning outcomes. This is because students are actively engaged in the learning process and are directly involved in preparing project designs to solve problems using physics concepts.

Differences in student physics learning outcomes occur due to differences in students' cognitive abilities, such as understanding complex information, connecting different information, and analysing a problem. In accordance with research conducted by Anggraeni (2020), the research results show that learning media in the form of games that are in accordance with the learning objectives can function to improve students' cognitive abilities. Games that are in accordance with learning objectives can serve to improve student achievement. Learning media in the form of appropriate games can be used as learning media to achieve optimal cognitive value. In addition, a supportive learning environment, both at school and home, can also affect student learning outcomes. Factors such as support from parents, the availability of adequate learning resources, and the physical condition of the classroom can also have an effect. This is in line with research conducted by Oktavian et al. (2023), which states that the application of QuizWhizzer media has a positive influence on student responses as it can improve learning outcomes on student responses as well as make student learning outcomes increase. This is because students feel more interested when solving the questions given by using QuizWhizzer media. Given by using QuizWhizzer media. Technology-based learning can make learning more interesting and relevant for students. This is evidenced by the involvement of students in the learning process who are

actively involved in finding solutions according to the given problem so that learning runs not only to understand the concept but also to better understand the concept itself.

Furthermore, this improvement in learning outcomes is corroborated by prior research by Putri et al. (2021), which explored the effect of the PBL model assisted by Quizwhizzer media on students' physics learning activities and outcomes. The results indicated increased students' physics learning activities and outcomes in both the control and experimental classes using the PBL model. In addition, in the opinion of Yusal et al. (2023), the results of data analysis from the application of problem-based learning models accompanied by visual media in physics education show significant differences compared to conventional learning methods.

CONCLUSION

The results of data analysis using the Mann-Whitney U Test, a non-parametric test due to abnormal data distribution, showed that the hypothesis test results for students' critical thinking skills resulted in a Sig (2-tailed) value of 0.038 <0.05. This indicates the rejection of H0 and the rejection of H0. This indicates the rejection of H0 and acceptance of Ha, which indicate a significant effect of applying problem-based learning models assisted by quiz whizzer media on students' physics critical thinking skills, especially on energy and its changes. Similarly, analysis using the Mann-Whitney U Test, a non-parametric test on students' physics learning outcomes, showed a Sig. (2-tailed) of 0.023 < 0.05. Once again, the rejection of H0 and acceptance of Ha indicates a significant effect of applying a PBL model assisted by quiz whizzer media on students' physics learning outcomes on energy and its changes.

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