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The Effectiveness of The Problem-Based Learning Model Assisted by Interactive Videos on Critical Thinking Skills

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Abstract

The 21st century demands that students develop various skills, including critical thinking. This study investigates how effective an interactive video-assisted Problem-Based Learning (PBL) model is in enhancing students' critical thinking skills on the topic of atomic structure and the benefits of nanomaterials. The research used a quasi-experimental design with non-equivalent control groups. The sample was selected using cluster random sampling, with class X4 as the experimental group and class X6 as the control group. Data were collected through pre-tests and post-tests, which were analyzed using the product-moment correlation formula to validate the test instruments. The results showed that the experimental group's average post-test score for critical thinking skills was 75.944, higher than the control group's score of 61.278. The hypothesis test using an independent sample t-test revealed a Sig (2-tailed) value of 0.000, which is less than 0.05, indicating that the alternative hypothesis (H_a) is accepted and the null hypothesis (H_0) is rejected. Additionally, the effectiveness of the model was assessed using the n-gain test, resulting in a mean value of 0.6327, which falls into the medium effectiveness category.

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1. INTRODUCTION

In facing the challenges of globalization and the rapid advancement of technology, the demands on students' competencies in the 21st century are increasingly rising. The 21st century demands that students possess a variety of abilities, including as critical thinking, problem-solving, effective communication, cooperation, and knowledge of information and communication technology (Partono et al., 2021). One of the abilities that pupils require in the twenty-first century is critical thinking. This is because students can think deeply about facing future challenges (Redhana, 2019).

Critical thinking is the process of thinking logically and reflectively in order to decide what one should trust or do (Ennis, 2015). Critical thinking skills are related to chemistry because they involve complex theories that require in-depth interpretation (Silberberg, 2009). Critical thinking skills are needed in learning activities in chemistry material to analyze indications or phonemes that appear (Cundo Manik et al, 2020). Based on interviews with chemistry teachers at SMAN 16 Semarang, it was found that students only listen to explanations without actively participating and also struggle to provide critical statements or answers. This demonstrates how students frequently struggle with critical thinking during learning activities because they prioritize memorization and comprehension over analysis, synthesis, and reflection (Zammi & Hakim, 2020).

To fully understand and appreciate the learning of chemistry, students must develop both conceptual and practical skills. Mastery of chemistry not only requires memorization but also the ability to apply theoretical knowledge to real-world situations. This process involves navigating a range of challenges that can be both intellectually demanding and complex. Chemistry is

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characterized by varying levels of difficulty in studying abstract and concrete concepts (Hatimah & Khery, 2021). One of the key topics in chemistry that students often find challenging is the study of atomic structure and the benefits of nanomaterials. According to a preliminary survey conducted among 11th-grade students at SMAN 16 Semarang, 55% of them reported difficulty in understanding these topics. The main reason is that, although atomic structure and the advantages of nanomaterials might seem straightforward, they involve abstract and complex concepts that are hard to grasp (Abubakar, 2022). Based on the problems mentioned, educators need to make improvements to maximize the learning model (Hasanah & Fitria, 2021). Students become disinterested in learning activities when the wrong learning model is chosen, hence, careful consideration of the learning model is necessary (Puger et al., 2024).

The learning model is a strategic step that includes learning planning, sketches for delivering materials, and guidance on an effective learning process (Rusman, 2010). According to the findings of numerous research studies, students find chemistry to be a challenging topic because they are not engaged, motivated, interested, or active in the subject; learning is still teacher-centered; and learning is boring (Fakhrurrazi et al., 2017; Anisa & Yuliyanto, 2017). The learning process centered around the teacher implies that students often lack insight into the framework used to generate concepts, leading them to simply memorize these concepts without truly comprehending them (Ningrum et al., 2022). This causes teachers to rarely link the material to a problematic topic. Students can be taught problem-solving techniques through the use of the Problem-Based Learning (PBL) model (Sabora et al., 2022).

PBL is a style of instruction that places students in real-life situations that are anticipated to strengthen critical thinking abilities, inquiry, compiling their knowledge, and developing independence and self-confidence (Arends, 2008). The characteristic of PBL is that all students work collaboratively to solve a problem given by the educator (Wulandari & Sholihin, 2015). According to the findings of a study by Zakiyah et al., (2023) on enhancing students' critical thinking abilities through the use of the PBL paradigm. The average score on the critical thinking exam was 69.375% in cycle I and 80.9375% in cycle II, indicating that critical thinking skills improved with each cycle, according to his research. The utilization of media in accordance with the material requirements of students supports the learning model's success. The use of media is one of the things that is needed and is an effective supporter in stimulating students' interest, attention, and motivation in learning activities (Nunu, 2012).

According to a preliminary survey conducted among 11th-grade students at SMAN 16 Semarang showed that 60% of students understood the material presented using video media better. Research conducted by Beny et al., (2020) found that the utilization of video content impacts students' critical thinking abilities. Interactive videos are a type of learning material that meets the needs of students today.

Concatenating interactive text, graphics, music, and movement components results in interactive videos and help by actively engaging students, boosting their motivation to learn and enhancing their understanding of the material in real-world contexts (Ardita et al., 2023). Interactive can control the learning process (Wardani & Syofyan, 2018). Students are encouraged through active participation in Problem-Based Learning (PBL). Interactive videos video components can present chemical concepts in various forms, helping to enhance students' understanding of the subject (Rati et al., 2022).

Based on the aforementioned issues, it was discovered that critical thinking abilities are still lacking in chemistry education, particularly when it comes to atomic structure-the benefits of nanomaterials. As a result, a learning model known as Problem-Based Learning (PBL) is required. PBL involves a problem and interactive videos to help students understand chemical concepts in a variety of ways.

2. METHOD

The research utilized in this study is quantitative with a quasi-experimental design. The use of experimental research is carried out to see the effect of independent variables that are influenced by dependent variables (Sugiyono, 2018). Quasi-experimental designs have experimental and control groups, but these control groups cannot control external variables that may affect the experimental class of students' critical thinking skills (Sugiyono, 2015a).

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The research population consisted of every student in class X at SMA Negeri 16 Semarang. The cluster random sampling technique was used for the random sampling. Cluster random sampling is a technique for determining samples if the scope of the object being studied is very broad (Sugiyono, 2023). In this research, class X4 was used as the experimental group, while class X6 served as the control group.

The data collection technique was carried out in several stages. First, monitoring the attitudes of individuals or groups to obtain data collection called observation (Sugiyono, 2015b). Second, conducting interviews was a method of data collection to explore the background of the issues based on the research being studied (Sugiyono, 2017). The interviews were conducted with the class X chemistry teacher at SMAN 16 Semarang. Third, applying a questionnaire involved using a variety of multiple-choice questions divided into the pre-research stage, which consisted of 13 questions. Fourth, collecting documentation aimed to gather supporting materials for the research being conducted. Fifth, giving a test to both the experimental and control classes using essay questions to assess the students' critical thinking skills in each group.

Data were analyzed statistically with SPSS 25. Several analytical techniques were employed, including: (1) To determine whether the sample data is normally distributed, the Kolmogorov-Smirnov normality test is used, with this test selected based on a sample size greater than 50; (2) the Levene test for homogeneity to assess whether the two treated classes had similar abilities; (3) In order to test whether that difference was statistically significant, an independent samples t-test was used, which is a parametric test and fulfills the prerequisites of normality and homogeneity; and (4) the N-Gain test to evaluate the effectiveness of a method or treatment.

3. RESULT AND DISCUSSION

This research aims to evaluate how effective a problem-based learning (PBL) model, supported by interactive videos, is for improving critical thinking skills in the context of atomic structure materials, specifically the benefits of nanomaterials. The research involved an experimental group using the interactive video-assisted PBL model and a control group using a traditional teaching method. To measure critical thinking skills, tests were developed based on indicators related to cognitive levels C4, C5, and C6. The critical thinking indicators assessed in this study include six key areas outlined by Ennis, (2015) that are: 1) focus, 2) reasoning, 3) inference, 4) situational awareness, 5) clarity, and 6) overview.

The question instrument was validated by 3 material experts. Their validation results indicated that 13 questions were suitable for use. The instrument was then tested on students from class XI MIPA 3 at SMAN 16 Semarang. The trial included 13 descriptive questions, which were analyzed using SPSS 25 to check for validity, reliability, difficulty levels, and the ability of the questions to differentiate between students. The analysis revealed that 12 questions were valid, and for the pre-test and post-test consisted of 10 essay.

A total of six grade X students from SMAN 16 Semarang constituted the population of the study. Normality and homogeneity tests are conducted on the population data. The data used comes from the final test scores of class X students at SMAN 16 Semarang in chemistry lessons. Normalization analysis was carried out using the Kolmogorov-Smirnov test to determine the level of equality of students' abilities and determine the class that would be used as the research sample. The findings are given in Table 1.

Table 1. Population normality test result

Class	Sig.
X 1	.065
X 2	.119
X 3	.159
X 4	.053
X 5	.200
X 6	.093

Table 1 indicates that the data were normally distributed. The results of the homogeneity calculation show a significance value of 0.906 > 0.05, which means the data is homogeneous. This research uses a sampling technique using cluster random sampling. Based on the analysis findings, the researcher chose the experimental class X4 and the control class X6.

This research is broadly divided into 3 stages, namely pre-test, treatment, and post-test. The time allocation lasts for six meetings, with 45 minutes per class hour. The experimental class learning activities apply the PBL model assisted by interactive videos, while the control class applies the conventional learning model using lecture and discussion methods.

Both classes took a pre-test at the start of the learning period to assess the students' initial skills. The mean pre-test score for X6 was 30.583, while the mean score for X4 was 35.111. Based on the results of the pre-test for both classes, it was found that the average score of students was still below the Minimum Completeness Criteria.

The learning activities of the control class and experimental class at each meeting, namely the second meeting, presented material about nanomaterials; the third was atomic structure; the fourth was electron configuration; and the fifth was the periodic system of elements and their tendency properties. The control class uses the usual method, namely conventional, and learning activities begin with a stimulus given by the educator.

Experimental class learning activities at the second meeting, the material studied was nanomaterials. Learning activities take place using the PBL model, assisted by interactive videos, and by applying the PBL syntax. The first syntax is problem orientation. The researcher explained one problem orientation, namely the Lapindo incident. These illustrations encourage students to pay attention, observe, and communicate actively. The activity was carried out with discussion and question answers. The question asked was, 'Do you know about Lapindo? Have you ever thought, Is there any benefit from the Lapindo accident?'. Students express their thoughts and find out the elements contained in Lapindo mud and their relationship with nanomaterials. In line with research by Susanti & Suwu, (2016) asking and answering questions is one of the learning activities that can develop thinking skills.

The second syntax is organization for learning. Researchers divided students into four groups to work on LKPD. Based on research by Klegeris & Hurren, (2011) which states that small group settings in PBL have a positive influence on students' learning and problem-solving skills.

The third syntax is for guiding group investigations. In this syntax, students can watch interactive videos about the size of nanomaterials via barcodes available in the LKPD, which can help students understand the material. According to Arif et al., (2019) the use of interactive media can stimulate students' concentration and involvement in learning. Students can collect data, analyze data by conducting literature reviews, and equate precession to solving problems.

The fourth syntax is the development and presentation of problem-solving results. Educators encourage each group to provide appreciation and input. Giving appreciation can build self-confidence and stimulate students' motivation to learn (Lestari, 2020).

The fifth syntax is analyzing and evaluating the problem-solving process. Activities that take place in this syntax include strengthening material, correcting errors, and making conclusions. Reinforcement is carried out as a form of response, both verbal and non-verbal, by providing feedback to students regarding their work as an act of encouragement or correction (Usman, 2013).

The research process at the sixth meeting included a post-test. The post-test is carried out to determine the final abilities of students. The results obtained were that the average value for the control class was 61,278 and the experimental class was 75,944. Based on the average value of the pre-test and post-test results from the two classes shown in Figure 1.

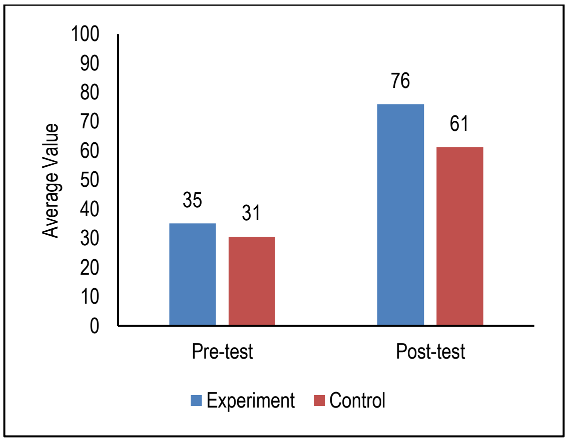

Figure 1. Average pre-test and post-test scores

Figure 1 illustrates the clear disparity in the mean scores between the two groups. This suggests that the critical thinking abilities of the experimental class improved more than those of the control group. As compared to the non-PBL class, students in the experimental class that employed the PBL methodology became more acclimated to solving issues, which is why they achieved a better average score (Apriyani et al., 2017).

Initial tests were required, such as homogeneity and normality testing. The information utilized for these

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assessments came from the pupils' pre-post and post-test scores.The results of the pre-test and post-test for both classes are presented in Table 2.

Table 2. Normality pre-test and post-test

Pre-test / Post-test	Class	Kolmogorov-Smirnov	Criteria
Pre-test	Experiment (X4)	.190	Normal
	Control (X6)	.123	Normal
Post-test	Experiment (X4)	.200	Normal
	Control (X6)	.199	Normal

The experimental and control classes' pre-test and post-test significance values were both over 0.05, according to the table. The data's normal distribution is thus confirmed. Following this, the Levene test was used to test for homogeneity. The results are shown in Table 3.

Table 3. Homogeneity pre-test and post-test

Levene Statistic	Sig	Criteria
2.910	0.92	Homogene

Based on the table above, the findings are significant for the variables related to critical thinking skills, as indicated by a significance value greater than 0.05, meaning the data distribution is homogeneous. Hypothesis testing was conducted by analyzing pre-test and post-test data. An independent samples t-test was used for hypothesis testing because the data met several criteria, including normal distribution and homogeneity of variance between the two groups. This test compares the average critical thinking skills of two different student groups. The results of the hypothesis test are presented in Table 4.

Table 4. Independent sample T-test

		Sig. (2-tailed)
Critical Thinking Skills Results	Equal variances assumed	.000
	Equal variances not assumed	.000

The Asymp value obtained for the Sig. (2-tailed) the test was 0.000, which is less than 0.05. This indicates that the alternative hypothesis (H_a) is accepted and the null hypothesis (H_0) is rejected. Therefore, it can be concluded that there is a significant difference in the average scores on the critical thinking skills test between the experimental and control groups after the treatment The effectiveness of the interactive video-assisted PBL methodology in improving students' critical thinking abilities in both groups was then assessed using an N-Gain exam. The improvement between pre-test and post-test scores is evaluated using the N-Gain test. Table 5 displays the results of this exam.

Table 5. N-Gain

Description	Class	
	Experimental	Control
N-Gain Score	0.6327	0.4523
Category	Medium	Medium

Table 5 according to the N-Gain score test computation, the experimental class's mean is 0.6327. While the control class's mean is 0.4523. According to Sudjana, (2005) regarding the N-gain test decision-making category, both classes are in the medium category.

Critical thinking abilities are the research variable in question. Ten essay questions are used to assess critical thinking abilities. Researchers in this study used five indicators, namely focus, reason, inference, situation, and clarity. This is because the overview indicator has easy criteria during the difficulty test. Eliminating questions that are too easy is because they cannot provide an accurate evaluation of students' critical thinking skills (Haynes et al., 2016). The percentage of critical thinking skills based on post-test indicators is presented in Table 6.

Table 6. Critical thinking indicator category

Indicator	Percentage (%)	Category
Focus	82	Excellent
Reason	73	Good
Inference	83	Excellent
Situation	75	Good
Clarity	65	Fair

The focus indicator is the student's ability to identify or understand the core of the problem. The focus indicator is in the excellent category with a percentage of 82% because students can hone their critical thinking skills to understand the problems raised to produce accurate analysis. This is consistent with the findings of research by Almunawarah et al., (2023) of 122 students, 72.13% were able to identify problems well, so the focus indicator was in the excellent category.

The reason indicator is the ability of students to identify reasons that support the core problem. The reason indicator is in a good category with a percentage of 73% because students can provide clear reasons regarding the answers given by connecting facts and arguments. This is consistent with the findings of research by Almunawarah et al., (2023) which said that of 122 students, 67.21% were able to provide logical reasons.

Inference indicators are students' ability to assess conclusions, assuming supporting and correct reasons. The inference indicator falls within the excellent category, with a percentage of 83%, as students are able to draw accurate conclusions and make precise predictions based on the data provided. Research conducted by Purbonugroho et al., (2020) stated that students' ability to conclude can be seen from the answers that have been completed logically.

The situation indicator is the student's ability to understand the situation carefully and apply the knowledge concepts they already have to solve different situations. The situation indicator meets good criteria with a percentage of 75% because students are able to adjust their thinking according to the problem situation so they can make the right decisions. Research conducted by Hayudiyani et al., (2017) which states that high-ability students can connect problem information well to solve problems.

The clarity indicator is the student's skill in providing further explanation. The clarity indicator has fair criteria with a percentage of 65% because students tend not to fully understand advanced instructions for the problems presented. This is in line with the statement by Metanoia et al., (2024) that students are unable to write down the work process coherently and perfectly.

4. CONCLUSION

According to the results of statistical tests and discussions, hypothesis testing performed using an independent sample t-test revealed an Asymp. Sig. (2-tailed) value of 0.000, which is below 0.05. This indicates the acceptance of H_a and the rejection of H_0. The acceptance of H_a implies that the Problem-Based Learning (PBL) model supported by interactive videos on atomic structure and the benefits of nanomaterials, effectively enhances students' critical thinking skills. Therefore, it can be concluded that using the PBL model with interactive videos is effective in improving students' critical thinking on these topics.

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