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Animation with problem-based learning to improve student higher-order thinking skills

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Abstract

This study aimed to determine the effectiveness of using interactive media based on 3 Dimension (3D) animation integrated with problem-based learning to enhance Higher-Order thinking skills in science classes for fifth-grade elementary school students. The research used a quantitative methodology with a quasi-experimental design to review the effectiveness of 3D-based animated media in quantity to improve elementary school students' higher-order thinking skills. The author selected 104 students as samples. Data from this study were collected through pretest and posttest techniques. The results indicated that learning with 3D-based animated media was effective with a value of sig = 0.00, which is smaller than = 0.05. It means that the results of the posttest in the experimental class were different from the control class. In addition to implementing effective 3D-based animated media, it also affected the students' higher-order thinking skills with an average of 83.87%. In conclusion, problem-based learning integrated with interactive media effectively improves students' higher-order thinking skills. This study contributes can broaden the insights of elementary school teachers to be able to apply 3D animation technology in classroom learning.

Keywords: 3 Dimension, animation, higher-order, thinking skills, problem-based learning;

1. Introduction

Learning media are tools or facilities used to conduct successful teaching (Batubara et al., 2022; Safitri et al., 2021; Sarifah et al., 2022; Tafonao et al., 2019). The media approach facilitates the path to the planned goals. Besides being able to attract students' interest in learning, the success of the learning process cannot be unconnected from the support of facilities (Edwita et al., 2020; Muhardini et al., 2020; Roddy et al., 2017; Safitri et al., 2022a; Susanto et al., 2022; Umasih et al., 2020; Milrad, 2013; Pitch et al.,2012).

Both conventional and multimedia-based learning are essential parts of education in schools, but the availability of learning media has so far been an obstacle or problematic (Hadi et al., 2022; Mupa & Isaac, 2015; Rapanta et al., 2020). Students need more practical, effectively visualised, and optimised learning time. Visualisation requirements could be fulfilled with the help of learning media (Ibrahim et al., 2020; Li & Tsai, 2017). The variety of learning media is one example of the development of science and technology in education (Elimelech & Aram, 2019; Fred Rogers Center, 2012; Marini et al., 2020).

This study had a gap from previous studies, as Xiao et al. (2013) revealed that audiovisual-based media could lead to boredom if it did not fit student needs. Furthermore, this study indicated that digital-based media for elementary school students could provide learning addiction if the teacher could not adjust to the learning topics. Another problem revealed by Piatykop et al. (2022) was that elementary school students preferred focusing on 3 Dimension (3D) pictures to the learning contents. In addition, Milner-Bolotin and Nashon (2012) revealed that students participated more actively while obtaining 3D-based media.

Hu and Wen (2019) said that students' critical thinking and questioning were triggered when the lesson was delivered through 3D-based media. These proofs of the gap were the reason to conduct this study, as primarily developed media were 3D-based. However, the novelty of this study raised and followed up the previous studies that were rarely developed and focused on 3D-based animated media on science subjects for elementary school students.

The demand for media usage in the learning process can be an effective solution by conducting learning conditions to become more accurate. Teachers can use various learning media: simply through conventional or multimedia-based teaching tools, known as interactive learning media (Kucirkova & Flewitt, 2020; Marini et al., 2022; Nuraini et al., 2020; Rihatno et al., 2020; Safitri et al., 2022b; Sujarwo et al., 2022).

Results of interviews with students revealed that students found it challenging to obtain the learning material. The students considered that science material was boring. The teaching materials used could have been more attractive to students. According to the findings of interviews with teachers, media to support learning in schools is limited. Therefore, learning media designed to provide concrete examples, such as animations, photos, images, etc., were highly required.

Most schools in Indonesia use exam instruments with dominantly 50% memorising questions, 30% understanding, and 20% implementation questions. This condition should not be expected to occur; the position of science subjects in education is critical (Göksu et al., 2017). Science is a subject at every level of education (Margot & Kettler, 2019). The elementary level is the basis for studying science subjects. Another reason is that science sharpens students' thinking, analysing, and designing skills to create a finding (Tachie, 2019).

Students need to be active learners who can define and analyse problems and find solutions (Flamboyant et al., 2018). Developing higher-order thinking skills is essential to familiarise students with something difficult, producing excellent and intelligent students in solving problems (Chasanah et al.,

2019). Lack of media usage in the learning process leads to the students' boredom (Bulunuz, 2013). Conducting learning for elementary school students should use concrete and various media (Marini et al., 2021; Puspitarini & Hanif, 2019).

With the help of attractive media, students will find it easy to understand the subject lesson, which is expected to positively impact students' thinking skills (Kamamia et al., 2014). Using media in learning will bring significant benefits as the learning process will be more conducive. Both teachers and students will provide feedback in the learning process and achieve optimal results (Tilchin & Raiyn, 2015).

In addition to using learning media, a learning model can stimulate students' higher-order thinking skills. One of the learning models is the Problem-Based Learning model. The Problem-Based Learning model presents one example of student-centered learning where learning occurs due to students' efforts to research, analyse, explain, and solve meaningful problems (Bellová et al., 2018). Given the broad access to technology, educators have shown great interest in using technology to support student-centered learning.

Problem-based learning is a centred learning model that allows students to conduct research, combines theory and practice, and implements knowledge and skills to advance viable solutions to specified problems (Clausen & Andersson, 2019). According to the preceding justification, the problem formulation is as shown in the following; How is the effectiveness of using interactive media based on 3D animation integrated with problem-based learning models to improve higher-order thinking skills in fifth-grade elementary school students?

2. Methods and Materials

2.1. Method

This study used quantitative methodology to review quantity and meaning (Chau et al., 2020; Patel & Patel, 2019) that 3D based animated media was effective to raise elementary school students' higher-order thinking skills. In addition, this study used a Quasi-Experimental research design with a non-equivalent Control Group Design type by comparing the average level of higher-order thinking of students before and after learning and comparing the experimental and control groups (Stephenson et al., 2019; Young et al., 2018). The research design is described in Table 1.

Table 1

Pre-Test and Post-Test Control Group Design

Group	Pretest	Treatment	Post-test
Experiment	O_1	X	O_2
Control	O_1		O_2

Table 1 displayed that the author conducted Pre-Test (O_1) for both the experimental and control groups and Treatment (X) for one of both groups in learning using 3D animated-based learning. At the end of learning, the author conducted Post-Test (O_2) for both the experimental and control groups. The author conducted this series of activities to determine the students' high-level thinking skills before and after the learning for those students in an experiment and the control group.

2.2. Materials

This study's subjects were fifth-grade students from public elementary schools in Central Java, Indonesia, with a total of 103 students as the experimental class. In comparison, the control group consists of 104 fifth-grade students from public elementary schools in Central Java, Indonesia.

Data was collected through test techniques. The tests presented are in description questions structure that can hone students' higher-order thinking skills. This description test will target fifth-grade elementary school students to determine the improvement of students' higher-order thinking skills before and after implementing 3D animation-based interactive media.

The indicators used are related to higher-order thinking skills, which consist of thinking levels of applying, analysing, evaluating, and creating. The instrument used in this research which can be seen in Table 2, is a test instrument that is useful for measuring the results of students' higher-order thinking skills.

Table 2

Higher Order Thinking Instruments

Indicator	Total of items	Cognitive process questions (Higher order thinking ability)		
		C4	C5	C6
Name the organs found in animals and their functions	3	√	√	√
Mention the digestive organs in humans and their functions	2	√		√
Comparing the digestive organs of animals and humans	2	√	√	
State the causes of disorders of the human digestive organs	3	√	√	√
Mention the disease that affects the human digestive organs	2		√	√
Mention the various diseases that attack the human digestive organs	3	√	√	√

The data analysis was handled to examine the differences in the learning outcomes of the experimental and control classes. The analysis used was a comparative test to test whether students' average higher-order thinking skills using 3D animation-based learning media can increase students' higher-order thinking skills. The hypothesis test used is the average difference test with the *t*-test formula. This test is then used to decide learning effectiveness with 3D animation-based learning media.

3. Findings

Based on information gained before the treatment, the school needed teachers who could conduct learning with digital-based media assistance. It was based on an interview with the teachers that they usually conduct conventional learning due to the need for more knowledge about digital-based learning media. Therefore, this study could be a novel thing for the school. In addition, science learning at school usually focuses more on theories than students' active participation.

Students had limited opportunities to give their opinions, argument, and discussion since they had teacher-centered learning. These findings revealed that some fields of learning needed improvement. The first solution to resolve the problem was shifting the learning method from teacher-centered to student-centered by shifting to digital-based learning media in science learning. It is quite interesting because the school provided facilities to encourage the development of attractive and innovative media. Besides, these findings were described as qualitative data as follows.

The effectiveness of interactive media based on 3D animation integrated with problem-based learning to improve higher-order thinking skills in science content in elementary schools is known through a two-sample difference test through a *t*-test. However, before the test of the difference

between the two averages (*t*-test) was carried out, the data analysis requirements were first tested by conducting a normality test and a homogeneity test. The normality test of the control class can be shown in Table 3.

Table 3

Normality Test of Pretest in Control Class

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Control class pre-test data	0.074	104	0.197	0.978	104	0.075

The sig value was obtained using the Kolmogorov Smirnov test assisted by SPSS. Of 0.197, which is greater than the specified = 0.05. Therefore, the pretest data in the control class of 104 students followed a normal distribution. The normality test of the experimental class can be displayed in Table 4.

Table 4

Normality Test of Pretest in Experimental Class

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experimental class pretest data	0.065	103	0.200	0.985	103	0.315

Using the SPSS Smirnov Kolmogorov test, SPSS is obtained. Of 0.200, which is more remarkable than α = 0.05 specified. Therefore, the pretest test data can be presented in the experimental class of 103 students following a normal distribution.

Table 5

Test of Homogeneity of Variances

Levene statistic	df1	df2	Sig.
0.472	1	205	0.493

Based on the homogeneity test using Levene's test in Table 5, the calculated value of 0.493 means that both data have homogeneous variances. Descriptive statistics of the pretest and posttest in experimental and control classes can be shown in Tables 6 and 9. The normality test of the posttest in control and experimental classes is displayed in Tables 7 and 8.

Table 6

Descriptive Statistics of Pretest in Experimental and Control Classes

	Class	*N*	Mean	Std. deviation	Std. error mean
Higher-order thinking skills	Experiment	103	56.26	10.625	1.047
	Control	104	55.73	11.129	1.091

Table 7

Normality Test of Posttest in Control Class

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Control	0.086	104	0.058	0.974	104	0.040

The sig value was obtained using the Kolmogorov Smirnov test assisted by SPSS. Of 0.086, which is greater than the specified =0.05. Therefore, the posttest test data in the control class of 104 students followed a normal distribution.

Table 8

Normality Test of Posttest in Experimental Class

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experiment	0.081	103	0.089	0.981	103	0.140

The sig. value was obtained shown in Table 8 using the Kolmogorov-Smirnov test of 0.089, which is greater than the specified of 0.05. Therefore, the posttest test data in the experimental class of 103 students followed a normal distribution.

Table 9

Descriptive Statistics of Posttest in Experimental and Control Classes

	Class	*N*	Mean	Std. deviation	Std. error mean
Higher-order thinking skills	Experiment	103	83.87	5.163	0.509
	Control	104	75.06	7.400	0.726

Table 10

Independent Samples Test

	Levene's test for equality of variances		*t*-test for equality of means						
								95% confidence interval of the difference	
	F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error difference	Lower	Upper
Equal variances assumed	13.677	0.000	9.932	205	0.000	8.816	0.888	7.066	10.566
Equal variances not assumed			9.948	84.212	0.000	8.816	0.886	7.068	10.564

Based on Table 10, it is presented that the homogeneity test results using the SPSS Levene test with the value of the α = 0.05 limit value obtained the value of sig = 0.00. This means that the posttest data for the experimental and control class is not homogeneous. Because it is not homogeneous, equal variances are not assumed, and the value of sig = 0.00 is less than α = 0.05, which means the two posttest results differ from the control class. The higher experimental class's average (mean) is higher than the control class, with a difference of 8.816.

4. Discussion

The average student learning outcomes of experimental classes using learning using interactive multimedia-based science teaching materials are significantly different from those of control classes using PowerPoint media in learning.

The N-Gain test was carried out to determine the increase in the value of the pretest and posttest. N-gain results in percentages indicate that the mean n-gain control class is smaller than the experimental class. For example, the percentage of the control class n-gain is 42.3722% which means that it means to be less effective at intervals 40–55. While the percentage of the N-Gain Experimental class is 62.7250%, it effectively improves students' higher-order thinking skills. The effectiveness of the developed media

was measured using the average difference test (*t*-test) by comparing the higher-order thinking skills in the experimental and control classes.

The test results using the SPSS-assisted Levene test with a limit value of = 0.05, the value of sig = 0.00 is obtained. This means that the experimental and control class posttest data are not homogeneous. Because it is not homogeneous, equal variances not assumed are chosen, and the value of sig = 0.00 is more minor than = 0.05, which means that the posttest results of the experimental class are different from the control class. As a result, the average (mean) of the experimental class is higher than the control class, with a difference of 8.816.

Thus, there is a significant difference between the average student learning outcomes between the experimental class using interactive media based on 3D animation and the control class using power point media in learning. So, interactive, integrated problem-based learning is feasible and effective in improving the higher-order thinking skills of elementary school students. Furthermore, the interactive media based on 3D animation that was developed was effective in improving higher-order thinking skills because it was developed according to the characteristics of fifth-grade elementary school students.

The finding of this study is similar to the research conducted by Ersoy and Baser (2014), presenting that implementing problem-based learning and applying a student-centered instructional strategy can raise the students' higher-order thinking skills. Furthermore, this method can put the students in charge of their learning, and the student's class participation is essential.

Urgency of innovative learning media is needed for the continuity of the learning process; one alternative, in this case, is combining technology-based learning media. Hu and Wen (2019); Kumar et al. (2019) found that animation can improve students' understanding when used in a way that follows the cognitive theory of multimedia learning. In addition, research from Sood and Xiao (2018) reports that 3D visualisation and 3D simulation into other teaching materials create a new immersive environment where students can gain knowledge and develop higher-order thinking skills.

This is consistent with Hussain et al. (2017), applying technology in education can improve students' learning outcomes and retention. In addition, this advanced technology can promote the students' activities and encourage their self-regulation. Therefore, learning effectiveness and quality will increase.

Similar to Cevahir et al. (2022) stated that the utilisation of animation could affect students' achievement. It was found that the characteristics of animation can make a tempting process of teaching and learning. In addition, it can stimulate the students by reducing the concept of abstraction by visualising the teaching material.

Fitriyani and Solihati (2022) affirmed that implementing advanced technology, such as animated videos, can stimulate students' understanding and make learning more enjoyable. It can assist the students in absorbing teaching material more effectively. It can support the students to be engaged productively in the teaching-learning process.

Ritonga et al. (2020) confirmed that the teaching-learning process by applying problem-based video animation could powerfully enhance students' High Order Thinking Skills. The problems given to the students were close to their daily lives, so they were getting involved constructively. Furthermore, video animation supplied more important visual occurrences of various situations and abstract facts.

5. Conclusion

The student's higher-order thinking skills can be enhanced using interactive multimedia-based science teaching materials. The test results use the SPSS Levene test with the α = 0.05 limit value obtained the value of sig = 0.00 less than α = 0.05, meaning the two posttest results differ from the control class. In addition, the higher experimental class's average (mean) is higher than the control class, with a difference of 8.816.

N-gain results in the form of percentages indicate that the mean n-gain control class is smaller than the experimental class. For example, the percentage of the control class n-gain is 42.3722% which means that it means to be less effective at intervals 40–55. On the other hand, while the percentage of the N-Gain Experimental class is 62.7250%, it effectively improves students' higher-order thinking skills.

6. Recommendations

The scope of findings' results in this study had a limitation that could only be implemented for elementary school students. The usage of learning materials just focused on science subjects for elementary school. Therefore, the 3D-animated learning media could only be used in classroom learning. The upcoming need for 3D-animated media is highly demanding, focusing on specific materials and school or grade level. The 3D-animated media could be a convenient and practical application for online and offline learning.

In conclusion, the result of this study could provide a significant contribution to teachers in developing constructive learning method innovation to encourage student learning motivation. Furthermore, the school could also collaborate in facilitating and supporting the improvement of a digital-based learning system by empowering teachers to strengthen technology-usage literacy. Furthermore, future studies should develop characteristics from 3D-based animated media that is based on student characteristics by considering the learning environment based on digital demand.

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