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3D Animation Media to Improve High-Level Thinking Skills

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Teachers facilitating student learning still need to be improved, and student participation in elementary school learning still needs to improve. Teachers need to create a learning atmosphere with various innovative interactive media. Currently, the use of technology-based learning media still needs to be developed. The purpose of the study is: (1) to determine the feasibility of interactive media based on 3D Animation integrated with the problem-based learning model that can improve high-level thinking skills in grade V elementary school students; (2) to test the effectiveness of interactive media development products based on 3D Animation integrated with the problem-based learning model, which can improve high-level thinking skills in the fifth-grade elementary school students. The research method used in this study is Research and Development with the ADDIE Model. The stages in the ADDIE model consist of analysis, model design, development, implementation, and evaluation. The population in this study was fifth-grade students, totalling 103 students consisting of 103 students. The instruments used in this study include a prototype assessment questionnaire, expert validation questionnaire sheets, interview guidelines, and high-level thinking ability tests. Data analysis techniques, such as the comparative and N-Gain tests, were used. The study results showed that expert validation was a very valid category, so interactive media based on 3D Animation can be used in learning. The results of using interactive media based on 3D Animation can improve students' high-level thinking skills. Hypothesis testing shows an influence, and the N-Gain test shows that the media effectively improves students' high-level thinking skills. Interactive media based on 3D Animation is good for improving the critical thinking skills of elementary school students.

Keywords: three-dimension animation, problem-based learning, high-level thinking skills, elementary school.

1. Introduction

The thinking skills that students must have, of course, are not only low-level thinking skills (lower-order thinking) but also high-level thinking skills (higher-order thinking) (Adeoye & Jimoh, 2023). Students with high-level thinking skills are not only required to remember or memorize; more than that, students must be able to develop their thinking skills (Lu et al., 2021). Developing high-level thinking skills is essential to accustom students to difficult situations, producing students who are superior and intelligent in solving problems (Edwita et al., 2019; Aniceto, 2023).

The application of higher-order thinking Skills (HOTS) is a 21st-century demand that students must have as a level of thinking process developed as a concept, cognitive method, and learning taxonomy (Gupta & Mishra, 2021). HOTS is measured through Bloom's Taxonomy, which has levels of C4 to C6 (Rasol et al., 2020). Tobón & Nemecio (2021) explained that there are at least complex thinking processes: problem-solving, decision-making, critical thinking, and creative thinking (Asbar et al., 2020). Lu et al. (2021) suggested that teachers should encourage students of all academic levels to engage in tasks that involve higher-order thinking skills.

In addition, Lo and Feng (2020) argued that higher-order thinking skills at the elementary school level are also challenges based on children's basic language and abstract thinking skills. On the other hand, higher thinking skills are critical in primary school, skills that are not only known from the beginning of learning activities but also require other higher skills in the form of analysis, evaluation and application (Wilson & Narasuman, 2020). Although students lack higher-order thinking skills, most are making significant progress in their analytical and methodological skills.

However, in reality, students are still less encouraged to be able to master higher-order thinking skills, one of which is (Karuru, 2023). Students need help mastering high-level thinking skills (Dekker, 2020), which is based on the Trends in International Mathematics and Science Study (TIMSS) and The Programme for International Student Assessment (PISA) reports. Where TIMSS shows that the percentage of students' correct answers to comprehension questions (C2) is always higher than application questions (C3) and reasoning (C4) (Mullis et al., 2019).

One of the causes of students' low high-level thinking skills at this international level is the need for more involvement of students in each learning process (Heron & Palfreyman, 2021; Lu et al., 2021). The role of students who are not involved in the information search process will make students bored (Net et al., 2023). This will undoubtedly hinder students' motivation in learning, so students need help acquiring high-level thinking skills (Mafarja et al., 2023). Another thing shows that students' science skills still need to improve. For this reason, students' science skills need to be trained in schools.

Preliminary studies through interviews with students obtained information that students still find it challenging to absorb the learning materials delivered, the teaching materials used in learning use the 2013 curriculum textbook, the media used by teachers to support learning in the form of images, and power points that are less interesting for students. The results of interviews with teachers obtained information that in delivering material, teachers use the

2013 curriculum textbook, the media to support learning in schools is limited, media development is more in the form of images, and materials in the form of power points. So, it is necessary to help with learning media designed to provide concrete examples, such as animations, photos, and images. Related to high-level thinking skills, teachers in developing test instruments have not fully used questions that hone high-level thinking skills; the proportion of questions is still dominated by level 1 question criteria as much as 50%, level 2 questions as much as 30% and level 3 questions as much as 20%.

The role of primary school teachers is to design better-quality lessons and implement learning activities or new activities related to students' thinking skills. Gupta and Mishra (2021) and Zakaria et al. (2021) proposed a series for developing higher-order thinking in the curriculum for grades 4-12, namely using computer simulations to demonstrate the complexity designed for students to make HOTS observations. The problems teachers face in learning management require constant improvement of their knowledge of learning media, methods, and strategies to provide lessons that match the needs of students in the classroom.

Failure to use media in the learning process leads to a lower level of thinking; students become bored with learning and only use temporary media (Hew et al., 2019), especially for elementary school students. With the help of engaging media, students will understand the topic, contributing to the student's learning outcomes (Sarwari & Kakar, 2023).

Many studies have proven that the role of multimedia can facilitate conceptual understanding and increase children's attention (Aaliyah, 2018; Banggur et al., 2018; Husein, 2019; Namiroh et al., 2018; Pardjono, 2020; Mena, 2020). Most of these studies were conducted on high school and high school students in the sciences and other fields. However, it is possible that multimedia can be used with primary school students. Many studies show that multimedia can be used in primary school children (Maizura et al., 2020; Rachmadtullah et al., 2019; SAPUTRI et al., 2018; S. Sumantri, 2015).

Linear studies conducted by Bron and Bario (2019) and Rihiati (2021) showed that multimedia could affect human higher-level cognitive skills such as problem-solving, hypothesis testing, decision-making, assessment and reflection. In addition, the research of Erdem and Adiguzel (2019) showed that multimedia development programs must be accompanied by growth and intellectual responsibility in students. Learning is more accessible in an environment with graphics (pictures, pictures, pictures) and audio information presented simultaneously than in an environment with only graphics and written words (Mayer, 2009). This means that it is very similar to multimedia, which combines text, graphics, audio, video and Animation to convey messages clearly and beautifully.

Currently, the use of media based on 3D Animation needs to be improved so that primary school teachers can use it as a learning tool (Facione, 2016). The transformation from 2D to 3D animation design requires the ability of technology to enable students to produce educational media (Demir & Akpinar, 2018). Animation is a collection of images that create a movement better than other media such as still images or text (Alonso et al., 2021). Animation captures students' attention and increases enthusiasm by drawing or moving images (Bahati, Mahsar et al., 2017).

Animation is one of the multimedia tools used to introduce the material to the students (Edri

et al., 2020). 3D Animation is a 3D image; the whole creation uses computer aid (Bhatti et al., 2017). 3D Animation is an extension of 2D Animation that allows viewing from different angles, making things look more realistic and closer to the original (Zhaker et al., 2021).

Based on the description above, this study aims to develop interactive media based on 3D Animation to improve high-level thinking skills. The objectives of this study are as follows: 1) To determine the effectiveness of interactive media based on 3D Animation integrated with a problem-based learning model to improve higher-order thinking skills in primary school students. 2) Testing the effectiveness of interactive media development products based on 3D Animation integrated with a problem-based learning model to improve higher-order thinking skills of fifth-grade elementary school students.

2. Methodology

The research method used in this study is Research and Development (R&D) with the ADDIE Model. The stages in the ADDIE model are: (1) Analysis, (2) Model design, (3) Development, (4) Implementation, and (5) Evaluation. The population in this study was 103 fifth-grade students. The instruments used in this study included a prototype assessment questionnaire, expert validation questionnaire sheets, interview guidelines, and high-level thinking ability tests. The data analysis technique used the T-Test and the N-Gain Test.

3. Results and Discussions

The first step carried out in this study was a needs analysis, which was done first to examine the current research needs in this area. Researched and analyzed learning problems in the context of learning in fifth-grade elementary schools. The information obtained from the needs analysis results was used as supporting data to strengthen the development studies. The design of educational platforms is based on 3D Animation as a learning medium. Educational media based on 3D Animation will look great on the home screen. There are many parts on the home screen.

The menu display in this exercise-based learning program includes many menu options in the form of core and basic skills, resources, assessments, information and instructions for use. These menus can be selected according to the user's needs, as shown in Figure 1. Users can select one of the resources they want to study. In addition to the games, this teaching program offers a survey containing questions as a final assessment material after the completion of the learning process. The purpose of assessment through tests is to measure students' thinking skills at a higher level. Figure 2 provides an illustration of the design and development of 3D learning media to improve higher-order thinking skills.

Figure 1. Display of material on interactive media based on 3D Animation

Figure 2. Game display and evaluation on 3D animation-based interactive media

Feasibility of interactive media based on 3D Animation

Assessment of Expert Validation

This study's experts are in language, materials, learning, graphic technology and tools, especially those who study higher-order thinking skills. Experts were selected based on their knowledge, ease of communication and experience in their respective fields. Product validation is done using the Delphi method. Once a test product is approved, all experts can assess the product and all related equipment. As a result, the cumulative results of expert validation are shown in Table 1.

Table 1. Recapitulation of expert assessment results on media development

Expert	Aspect	Item	Validator		
			1	2	3
Learning Media	Ease of navigation	5	24	24	24
	Content of cognition and presentation of information	7	34	35	35
	Integration of media	3	15	15	15
	Artistic dan aesthetic	7	35	35	35
	Overall Function	3	15	15	15
Total score			123	124	124
Average			4.92	4.96	4.96
Material	Quality of content and purpose	10	46	46	48
	Quality of learning	10	49	49	49
Total score			95	95	97
Average			4.75	4.75	4.85
Language	Eligibility to student development level	3	14	15	13
	Communication	5	24	22	24
	Consistency and integration of thought flow	2	10	9	9

Score	48	46	46
Average	4.8	4.6	4.6

The statistical results can be explained in Table 1, and the development of the media is described; the expert assessment is done first through the given tool sheet. These three experts cover educational media, materials and language. At the same time, they submit their assessment. Over approximately one month, input and feedback were provided from the results of expert reviews for revisions or revisions and a review of the member review process until the appropriateness of the method developed for pilot testing (Yazon et al., 2019).

The result is that the three experts or supporters evaluated the main characteristics of the knowledge base; that is, the average score of the three experts was equal to the average of 4.96. In addition, the independent assessment based on information has a mean score of 4.75, and the assessment based on language has a mean score of 4.6. This shows that expert evaluations can also be used to test developed media.

Trial Test of Teacher as User

The user test stage is a trial conducted on elementary school teachers. This trial was conducted by distributing questionnaires to teachers to provide assessments of 3D-based interactive media on science content. The questionnaire instrument consisted of 25 assessment items with a scale range of 1 - 4. The average scores were then categorized according to eligibility level and the specified data reference. The user trial was conducted by giving questionnaires to 3 elementary school teachers. The results of the user trial assessment are indicated in Table 2. Based on Table 2, the results of the user trial assessment on 3D-based interactive media show a percentage of 95, 94 and 96 with an average rate of 95, which is included in the very valid criteria but needs to be revised according to criticism and suggestions so that it is suitable for use.

Table 2. Teacher User Trial Results

Aspects	Items	maximum score	Respondents		
			1	2	3
Content Quality	8	32	30	30	31
Language	5	20	19	19	19
Implementation	6	24	22	23	23
Display	6	24	24	22	23
Total value	25	100	95	94	96
Average			3.80	3.76	3.80
Percentage			95%	94 %	96%

Trial Test of Student as User

After experts and teachers assess the developed media, students test the developed media for readability in the next stage. This is done to ensure that the developed media practically has its function.

One-to-One Trial Test

The one-to-one trial stage is the first trial conducted on elementary school students. In the individual trial, the researcher explains the role of interactive media and how to use it for students, and then the researcher asks them to try using the interactive media. The aim is to determine their response to or reaction to using this interactive media. This trial was

conducted by distributing questionnaires to students to provide assessments related to interactive media based on 3D Animation on science content. The questionnaire instrument consisted of 15 assessment items with a scale range of 1 - 4. The average score results were then categorized according to the feasibility level and the specified data reference. The one-to-one feasibility test was conducted with 3 students with different abilities and characteristics. The results from the one-to-one trial are displayed in Table 3.

Table 3. One-to-One Trial Test Results

Aspects	Items	maximum score	Respondents		
			1	2	3
Content Quality	8	32	30	30	31
Language	5	20	19	19	19
Implementation	6	24	22	23	23
Display	6	24	24	22	23
Total value	25	100	95	94	96
Average			3.80	3.76	3.80
Percentage			95%	94 %	96%

Based on Table 3, the results of the user trial assessment on 3D-based interactive media show a percentage of 93, 97 and 92 with an average of 94, which is included in the very valid criteria but needs to be revised according to criticism and suggestions so that it is suitable for use.

Small Group Try-Out

The small group try-out stage is the second trial conducted on elementary school students. In the small group try-out, the researcher explained the role and how to use this interactive media to the students, and then the researcher asked them to try using the interactive media that was developed. The aim was to determine their response or reaction when using interactive media with a more significant number. This trial was conducted by distributing questionnaires to students to provide an assessment related to 3D-based interactive media on science content. The questionnaire instrument consisted of 15 assessment items with a scale range of 1-4. The average score results were then categorized according to the feasibility level and the specified data reference. The small group feasibility test was conducted with ten students with different abilities and characteristics (Marini et al., 2018). The following is a table of data from the Small Group Try-Out questionnaire. Based on Table 4, the small group trial assessment results on 3D-based interactive media show a percentage of 93.8, included in the very valid criteria but needs to be revised according to criticism and suggestions to be suitable for use.

Table 4. Small Group Trial Test Results

Aspects	items	maximum score	Final score
Material	4	16	146
Language	2	8	74
Display	5	20	191
Implementation	4	16	152
	15	60	563
	Average 37,53		
	Percentage 93,83		

Research Instrument Test

Before collecting data in the field, a test instrument test was carried out that would be used in the Pretest and Posttest. This validity test is used to show the extent to which the measuring instrument is used in measuring what is being measured, while the reliability test is helpful for measuring the consistency of a test, namely the extent to which a test can be trusted to produce consistent scores.

Test of Validity of High-Order Thinking Ability Test

The critical thinking skill test instrument questions that were tested consisted of 25 questions. The instrument validity measurement was measured using Pearson product-moment. Based on the validity test results, out of 30 questions, there were six invalid questions, namely numbers 6,9, 22,23,29 and 20. The calculation of question validity is in the appendix

Reliability Test of High-Order Thinking Ability Test

The calculation of instrument reliability is intended to determine the extent to which the science learning outcome instrument can be trusted or relied upon as a data collection tool. This reliability test uses Alpha Cronbach. The table shows that the overall test reliability is 0.943, the r table is searched at a significance level of 5%, and the r table = 0.361. Therefore, r count> r table the questions in this research instrument are said to be highly reliable or trusted as a data collection tool in research. The calculation of question reliability is in the appendix.

Effectiveness of 3D animation-based interactive media

The effectiveness of this interactive program was tested on 103 fifth-grade students. This large-scale experiment was designed to test the effectiveness of interactive media based on 3D Animation integrated with problem-based learning to improve high-level thinking skills in science subjects. In implementing this large-scale experiment, learning activities were conducted by comparing an experimental class that used science teaching materials through interactive media based on 3D Animation and a control class that used a learning method.

The effectiveness test was carried out with a Quasi Experiment designed to measure the high-level thinking skills of elementary school students by providing a high-level thinking ability test in the form of 15 essay test questions.

Table 5. Average Pretest High-Order Thinking Skills

Class	number of students	ideal score	highest score	lowest score	Average
Control	104	100	77	28	55,72
Experiment	103	100	77	27	56,21

The results of the simple pretest data test from the control classes and the test using the Kolmogorov Smirnov test using SPSS can be seen in Table 6. In the control class a sign. A value of 0.197 was obtained, more significant than the set $\alpha = 0.05$. Therefore, it can be concluded that the pretest data in the control class of 104 students follows a normal distribution. At the same time, the test class obtained a significance value of 0.200, which is greater than the set $\alpha = 0.05$. Therefore, it can be concluded that the pretest data in the test class of 103 students follows a normal distribution.

Based on the homogeneity test using the Levene test, a calculated value of 0.493 was obtained, which means that both data have homogeneous variances as presented in Table 6. The average equality test (t-test for Equality of Means) assisted by SPPSS for the experimental and control classes' pretest data obtained a sig value = 0.726. This result is more significant than α=0.05, so the control and experimental classes have similar means.

Table 6. Posttest Average of Higher Order Thinking Skills

Class	number of students	ideal score	highest score	lowest score	Average
Control	104	100	90	60	75
Experiment	103	100	95	73	84

The normal test of the control class's posttest data and the experimental classes' posttest data are calculated using the Kolmogorov-Smirnov test using SPSS software. The results of the posttest of the management class using the Kolmogorov-Smirnov test using SPSS achieved a significant value of 0.086, which is greater than the set α = 0.05. Therefore, it can be concluded that the posttest data in the control class of 104 students follows a normal distribution. At the same time, the test class reaches a significant value of 0.089, which is higher than the set α = 0.05. Therefore, it can be concluded that the posttest data for the test class of 103 students follows a normal distribution. Table 7 shows the descriptive statistics, showing that the experimental class's mean is higher than that of the control class and that the standard deviation is lower than that of the control class.

Table 7. Descriptive Statistics

Class	N	Mean	Std. Deviation	Std. Error Mean
Experiment	103	83.87	5.163	.509
Control	104	75.06	7.400	.726

Table 8. Independent Samples Test

	Levene's Test Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	13.677	.000	9.932	205	.000	8.816	.888	7.066	10.566
Equal variances not assumed			9.948	184.212	.000	8.816	.886	7.068	10.564

The test of the meaning of the control class's posttest data and the experimental classes' posttest data, the homogeneity test results using SPSS and the cut-off value α = 0.05, obtained the value of sig = 0.000, as shown in Table 8. This means that the posttest data for the experimental and control classes are not the same. Since it is not equal, equal differences are not considered, and the value of sig = 0.00 is obtained, which is less than α = 0.05, which means that the two results are different after the test in the test class in control. Class. The mean (mean) of the experimental class was higher than that of the control class, with a difference of 8.816. The results of the N gain in percentage show that the average N gain is lower for the control class than for the experimental class. The N-Gain percentage of the control class is 42.3722%, which means it is less efficient because it is in the range of 40-55. Because in the distance 56-75.

The independent sample t-test in Table 8 shows a difference in the average N-Gain of students' high-level thinking skills between the experimental and control classes. In addition,

the results of the N-Gain test show that using interactive media based on 3D Animation has proven effective in improving the high-level thinking skills of grade V students. From this, interactive media based on 3D Animation can improve the high-level thinking skills of grade V Elementary School students. This is evidenced by the test results showing an increase between before and after the implementation of learning using interactive media based on 3D Animation. Thus, interactive media based on 3D Animation integrated with the problem-based learning model developed by researchers can solve the problems of teachers and students in the field in terms of science learning.

3D animation learning media in science subjects improves students' high-level thinking because it is developed according to the characteristics and learning needs of grade V Elementary School students; this Learning media has several functions. There are two main functions in learning media, namely (1) Learning media as a learning aid and (2) Learning media as a learning resource. According to Clark & Mayer (2016), students can learn better from Animation and voiced narration than from Animation and text on the screen display. Images and words equally presented visually (i.e., Animation and text) will cause the visual channel to be overloaded while the auditory/verbal channel is not utilized. Interactive media based on 3D Animation has been adjusted to the characteristics of elementary school children.

In line with Bruner's theory, a person's cognitive development occurs through three stages: enactive, iconic, and symbolic (Takaya, 2008; Tampubolon, 2018). In elementary school, children go through the iconic phase and enter the symbolic phase. Children have begun to understand objects through images, recordings, or verbal visualizations at this stage. Interactive learning media positively influences student learning outcomes Rachmadtullah, Zulela, & Sumantri, (2018). Interactive media based on 3D Animation is very practical for supporting science learning. Currently, technology-based learning and the use of innovative learning media can increase teacher learning productivity in schools. 3D animation-based learning media is created to present real objects formed in 3D Animation into learning, thus enabling students to gain new experiences in learning without having to see the object's original form.

4. Conclusions

Based on the feasibility test of 3D animation interactive media products consisting of an average of 9 material experts consisting of 3 material experts, three language experts, and three media experts and three practitioners, it was stated that interactive media based on 3D Animation based on integrated problem-based learning is valid for use as a science learning medium for fifth-grade elementary school students.

Based on the effectiveness test involving 103 students, a t count of 0.05 was obtained, indicating that there was a difference in the average high-level thinking skills of students between the experimental class and the control class so that 3D animation learning media in the science subject matter was considered feasible to use and effective in improving students' high-level thinking.

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