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INCREASING MATHEMATICAL PROBLEM-SOLVING ABILITIES USING VIDEO TUTORIALS OF THE THREE-DIMENSIONAL COORDINATE SYSTEM IN SPATIAL ANALYTIC GEOMETRY

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ABSTRACT

Because students were having trouble picturing the three-dimensional system of coordinates in a spatial analysis geometry course, their mathematical problem-solving abilities were still low. Educational movies that aid in visualization are essential for pupils. The study at hand used a design consisting of a pretest-posttest control group and was quasi-experimental in nature. While the control class experienced conventional teaching, the learners in the experimental group learned using three-dimensional coordinate system audiovisual media. A test of one's capacity to solve mathematical problems was used, along with observation sheets and interviews. A total of thirty-four participants made up the sample for this study, which was carried out at the University of Pattimura's Mathematics Education Study Program. Evaluation was of t-testing outcomes on mathematical problem-solving skills. The findings demonstrated that students' proficiency in solving problems with mathematics increased when they were taught to use a video about the three-dimensional coordinate system.

Keywords: learning video, three-dimensional coordinate system, spatial analytic geometry, mathematical problem-solving.

INTRODUCTION

According to the National Council of Teachers of Mathematics, it is necessary to be capable of meeting the challenges of the advancement of science and technology in the twenty-first century, there are several mathematical skills that must be mastered, namely mathematical connection abilities, mathematical reasoning and proof abilities, mathematical representation abilities, mathematical communication abilities, and problem solving abilities (Nahdi, 2019). Mathematical connection ability refers to being able to connect various concepts such as connecting concepts in mathematics, apart from that, being able to also relate mathematical concepts to other fields in non-mathematics and even linking them to everyday life (Bakhril et al., 2019; Puteri & Riwayati, 2017). Students who have the ability to carry out analysis or carry out thinking activities in order to reach conclusions or produce a

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statement whose truth has been previously proven with the aim of getting a solution to the problem, making conclusions, then the student has the ability to reason (Putri et al., 2019; Nursoffina & Efendi, 2021).

The capacity to communicate ideas and concepts related to mathematics in a variety of formats, such as tables, graphs, drawings, mathematical notation, numbers, characters, and symbols, as well as verbally, is known as representation ability (Suningsih & Istiani, 2021; Herdiana et al., 2019). Since problem solving represents one from the five mathematics talents which pupils need to possess, it is required of them to be able to solve mathematical problems. Mathematical problem solving abilities according to George Polya (Halimah, 2019; Yuwono et al., 2018) comprise recognizing the issue you're facing, coming up with a strategy to address it, carrying out the plan's recommendations, and reviewing the outcome of the solution. These four procedures don't have to be followed in order for students to be able to answer mathematical issues. Rather, they will all support students' abilities to reflect, ponder, and interpret problems. In the period of the fifth industrial revolution, problem-solving skills are highly valued due to the numerous changes and challenges that face both daily life and college education. The way that learning is implemented on campuses has changed as a result of the corona virus, which has affected the entire world, notably Indonesia. Learning that was formerly done offline, or outside of the network, has shifted to online, or within the network.

During the academic year 2020–2021, online learning takes place through lectures on odd and even semesters. In the odd semester of 2020, one of the required courses is space analytical geometry. Online instruction is used for this course. For students, space analytical geometry is essential because it provides the foundation for comprehending geometric equations in three dimensions. Students must be qualified to answer problems like converting one point from cylindrical coordinates to Cartesian coordinates and vice versa for this course. Points in cylindrical coordinates are converted to Cartesian coordinates and students must even be able to solve the problem of changing points in cylindrical coordinates to spherical coordinates. Even though this course is important, facts in the field show that mathematical problem solving abilities in the spatial analytical geometry course still need to be improved. This can be seen from the results of space analytical geometry lectures in the odd semester of 2020-2021. Of the 80 students who attended the lecture, it turned out that there were still 20 students or around 25% who got a C grade and 13 students or around 16.25% got a D grade.

Furthermore, students struggle to understand spatial analytical geometry material, particularly when asked to solve problems involving points, lines, and planes in space because they find it difficult to imagine, relating to research by Mas'ud (2021) and Haryadi & Nurmaningsih (2019). A high error rate was discovered when students' errors in answering problems related to straight line equations in analytical geometry courses were examined. This covers a third of all pupils, which is a huge number. The majority of students still believe that studying space analytical geometry is a very challenging topic. The requirements of students for instructional materials in the course on spatial analytical geometry were examined by Pebriani et al., (2021). According to the investigation, students need learning resources that help them visualize since solving issues in space geometry requires them to be able to visualize a shape. Learning movies are one type of multimedia that can assist students in seeing three-dimensional problems so they are able to resolve them. One type of media that makes use of technical advancements is instructional films.

Video can summarize many events that have a long duration and are converted into a short and clear duration, equipped with images and sound. Videos can be played repeatedly according to user needs. One of the advantages of using learning videos is that they make it easier for students to visualize. Based on observations in the field, the majority of students have difficulty visualizing three dimensions. Some of the obstacles experienced are not being able to imagine the concept of space, lack of ability to describe or illustrate three-dimensional shapes(Novita et al., 2018) (Parlindungan et al., 2020). This conclusion is consistent with what was discovered of a study by Ramadhani & Silitonga (2023) that examined the learning materials that students enrolled in the spatial analytical geometry course needed. Students need learning videos with clear images, not just writing, presenting various questions with explanations, the questions displayed include questions with easy, medium and difficult levels of difficulty. Students need videos that use the Geogebra application. In the analytical geometry of space course, three-dimensional coordinate systems discuss coordinate systems, planes and plane lines, spheres, cylinders and cones, and second degree planes. In the coordinate system, we will study rectangular coordinates, cylindrical coordinates, spherical coordinates, distance between two points, comparison of line segments, as well as the scalar product of two vectors and vector product.

Among the benefits of using videos in the classroom are their accessibility, which enables learners to use them whenever and wherever they choose, giving them the flexibility to study for as long as they want. Due to the audio-visual format of three-dimensional coordinate system instructional films, students' motivation and interest in learning will rise. With all of the benefits of using instructional films, pupils can solve mathematical issues. (Dirgantoro et al., 2021; Sitinjak, 2022; Astra et al., 2014; Ikashaum et al., 2019). The ADDIE approach is useful to create educational videos. Because it is clear, easy to use, and includes evaluations at every step, the ADDIE development model is a concise development model that is also more dependable. (Muna & Wardhana, 2022; Tesalonika et al., 2022; Herwati, 2019). According to research findings by Harefa & La'ia (2021), using instructional videos has been shown to enhance abilities to solve problems. Students of Hiliganowo Village's class VIII junior high school participated in the study. The group consisting of pupils who obtained instruction through videos had an average problem-solving score of 65, whereas the group of students who did not receive instruction through videos had an average score of only 58. According to Partayasa, Suharta, dan Suparta (2020), using learning films can greatly enhance problem-solving skills.

Regarding to the findings of student interviews, students stated that they needed to learn to use video when learning three-dimensional material since it would make visualization easier for them. Furthermore, pupils stated that they preferred learning via video over books because the appearance was more appealing and noises could be heard. Another challenge that students experience while learning from video sources on the Internet is that there are frequently inconsistencies in the usage of symbols, terms on the coordinate system material, and the lecturer's symbols or terms.

From the interview results, it is known that students find learning using videos very interesting and increase students' motivation to learn (Nafilah et al., 2021). Based on the background explained previously, the researcher conducted research on "Mathematical Problem Solving Ability Through Developing Three-Dimensional Coordinate System Learning Videos in Spatial Analytical Geometry Courses". This video focuses on three-dimensional coordinate systems including Cartesian coordinates, cylindrical coordinates, and spherical coordinates. This learning video contains various three-dimensional coordinate system questions accompanied by discussions.

LITERATURE REVIEW

Mathematical Problem Solving Ability

George Polya is a pioneer in mathematical problem solving. Problem solving is the process of applying existing information to new unknown situations in such a way that it connects to the knowledge of the problem's essence. According to Polya, problem solving is important since it is necessary and crucial for pupils to have a sound understanding in order to solve complicated and non-routine problems. Students can solve difficulties by first analyzing the problem, developing or designing a solution strategy, executing it in problem solving, then re-examining the results of their effort (Ilmiyah & Fitri, 2020).

According to Nurvela et al., (2020) in solving or resolving mathematical problems, of course each student has a different method/strategy. This is caused by internal factors, namely their readiness and intellectual ability which can influence how to respond to these problems. In short, students need several conditions, namely having knowledge, skills and understanding in order to solve various problems. Learning to use various scientific methods or thinking that must be systematic, logical, orderly and thorough must be implemented to successfully solve problems.

In general, according to Polya, there are four stages of problem solving that are used as a basis for solving a problem, which can be described as follows. (1) Understanding the Problem. In the aspect of understanding the problem, it is necessary to identify what is known, what exists, the amounts, relationships and values involved and what they are looking for. (2) Make a Plan. In this aspect, identifying the operations involved to solve the given problem. (3) Implementing the Plan. What is implemented depends on what has been planned beforehand, interpreting the information provided into mathematical form, and implementing the plan during the process and calculations that take place. (4) Check Back. What you need to pay attention to is double-checking important information, checking all the calculations involved, considering whether the solution is logical, looking at other alternatives, and reading the question again and asking yourself whether the question has really been answered (Yuwono et al., 2018). The mathematical problem-solving ability indicator used in research is the Polya step.

Three-Dimensional Coordinate System in the Analytical Space Geometry Course

Geometry is a branch of mathematics studied from elementary to high school levels. Furthermore, in tertiary institutions geometry is still required to be studied by Mathematics Education students (Kurniasih, 2017). Geometry in higher education consists of plane geometry, space geometry, transformation geometry. Space analytical geometry is a course that studies coordinate systems, planes and plane lines, spheres, cylinders and cones, and second degree planes. In the coordinate system, we will learn about Cartesian coordinates, cylindrical coordinates, spherical coordinates, distance between two points, comparison of line segments, as well as the scalar product of two vectors and vector product. The learning outcomes of the coordinate system are a) drawing the coordinates of a known point in the arrangement of the x, y, and z axes; b) converting the coordinates of a point in a rectangular coordinate system to a cylindrical coordinate system and changing the coordinates of a point in a cylindrical coordinate system to a Cartesian coordinate system; c) changing the coordinates of a point in a Cartesian coordinate system to a spherical coordinate system and changing the coordinates of a point in a spherical coordinate system to a Cartesian coordinate system; d) calculate the distance between two known points; e) calculate the coordinates of a point on a known line segment for a certain ratio; f) calculating the vector product of two vectors, g) calculating the size of the angle between two vectors (Moma, 2015).

Learning Video of Third Dimensional Coordinate System

Learning videos are an example of media that utilizes technological developments combining sound and visual technology together. Using learning videos has many advantages, including ease of use. Video in form Video Compact Disc (VCD), Digital Video Disc (DVD), flashdisk and YouTube are easy for students to access anywhere, not just on campus but also at home. Students can study via video without time limitations, not only can they study during lecture hours but also outside lecture hours. Furthermore, learning by utilizing videos can maximize learning outcomes by up to 75 percent (Krisna & Marga, 2018). Several research results revealed that students need learning videos in spatial analytical geometry courses because the majority of students have difficulty visualizing in three dimensions (Ikashaum et al., 2019). Results of analysis of learning video needs that students need It was explained that the specifications for learning videos include having clear and interesting images; sound can be heard well; explanation of the material is complete and easy to understand; various questions with difficulty levels from easy, medium, and difficult; questions are equipped with discussions.

In the analytical geometry course, the main material on three-dimensional coordinate systems discusses coordinate systems, planes and plane lines, spheres, cylinders and cones, and second degree planes. Coordinate systems study rectangular coordinates, cylindrical coordinates, spherical coordinates, distance between two points, comparison of line segments, as well as scalar products of two vectors and vector products. Learning through three-dimensional coordinate system learning videos will increase student motivation and interest in learning because it is in audio-visual form. The research results of Rosiyanti, Eminita, dan Riski (2020) explain that all the advantages of using learning videos enable students to be able to solve mathematical problems.

RESEARCH METHODS

There are two stages carried out in this research, the first uses a development method aimed at producing learning videos. The development model used to develop a video coordinate system in three dimensions is none other than the ADDIE model. Learning videos can be developed using the ADDIE model. According to Wahyuny (2017) and Tesalonika, Parmiti, & Sudatha (2022) the ADDIE development model is a concise development model that is easier to implement and reliable because it is concise, simple and at each stage of the ADDIE model an evaluation is carried out. Videos developed using the ADDIE model are tested to determine the level of video feasibility. The test subjects consisted of 3 people who were competent in the field of mathematics, namely UNPATTI Mathematics Education lecturers to see whether the learning videos were in accordance with students' needs and the results were valid. Furthermore, to determine the improvement in learning by using learning videos that have been developed in the spatial analytical geometry course to measure mathematical problem solving abilities, quasi-experimental research was carried out in the 2022-2023 academic year, the design chosen was a pretest and posttest control class design. Two classes were given different treatments to see differences in improvements in the cognitive domain. The experimental class, consisting of 19 students, was given lectures using video, while the control class, consisting of 17 students, attended conventional learning. The test instrument used is a test sheet in the form of a description question sheet.

The validity test findings are as follows: 1. 0.724; 2. 0.774; 3. 0.726; 4. 0.832; and 5. 0.754. The validity of the matter is highly interpreted. The test result is 0.642 with a medium interpretation. The exam differentiator is good in all areas, and the difficulty level is medium. Data processing and analysis based on statistical testing of beginning, final, and quality data of improvement (normalized gain). The following is the normalized gain formula:

$$\text{normalized gain} = \frac{postest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

The n-gain criteria is high for g 0.7, medium for 0.7 > g 0.3, and low for g> 0.3. SPSS 25 is used for data analysis. A normality and homogeneity test is performed to identify the type of average difference test utilized. Furthermore, a mean difference test employs a t test for data that is normally distributed with homogeneous variance. The 5% level of significance was applied. Hypothesis test is Pupils who got experimentation outperformed pupils who underwent regular instruction in terms of growth in their ability to solve problems with mathematics.

RESULT AND DISCUSSION

This section will outline the analysis and discussion of the research findings about the ability of students to solve mathematical inquiries through the use of movies that demonstrate the three-dimensional coordinate system. The problem formulation was addressed by means of an analysis of the research data. The program SPSS twenty-four and the Microsoft Office Excel 2016 application are used to process the acquired data. The study findings that will be discussed include an examination of the pupils' aptitude for solving mathematical problems. We shall explain the explanation in the following manner.

Pretest and posttest results are among the problem-solving ability data that will be handled and examined in this study. As previously mentioned, the purpose of this study is to ascertain how much students' ability to solve problems in mathematics can be enhanced by watching instructional videos while learning the subject. This can be ascertained by contrasting the experimental class's and the standard class's accomplishment outcomes prior to and following they received various treatments. The pretest scores represent students' initial competence to solve mathematical problems before receiving treatment, while the posttest scores show students' final abilities to understand mathematical problems after receiving treatment. The normalization gain value (n-gain), which is derived by summing the pretest, posttest, and ideal maximum scores, indicates the caliber of improvement.

The data presented in table 1 indicates that the learners in the conventional course and the experimental one had initial scores of 29.59 and 28.26, respectively, for how well they were able to solve mathematical problems. It is evident that there is just a 1.33-point difference between the two classes' average beginning scores on mathematical problem solving skills. likewise it was seen that both the innovative and traditional classes' average scores for their capacity to solve mathematical issues had improved following the completion of the learning activities. The increase was 42.53 for the experimental group and 31.47 for the control class. The improvement in students' scores on the previous and subsequent tests for mathematical problem solving skills implies that each class's mathematics instruction has been effective in fostering students' growth in this area.

Table 1. Descriptive Statistics of Mathematics Promblem Solving Compentency Scores

	Control Class					Exsperimental Class				
	n	$\bar{x}$	s	x_{min}	x_{maks}	n	$\bar{x}$	s	x_{min}	x_{maks}
Pretest	17	29.59	5.08	22	40	19	28.26	3.87	22	34
Postest	17	61.06	13.69	36	80	19	70.79	9.53	58	88
N-gain	17	0.45	0.17	0.18	0.70	19	0.59	0.13	.,40	0.81
Ideal Maximum Scores : 100										

If discovered, nevertheless, the mean posttest scoring disparity among the two separate categories came to 3.58. This number is eight times higher than the typical variation in the prior test results. It also implies that by the time they finish their education, students in the experimental class have far better advanced ability to solve mathematical issues than those in the regular class. It was also evident from the first table above that no students in the experimental or control classes received an n-gain score of zero. This indicates that following the completion of learning activities, both experimental and control, all students saw a rise in their results. The following table 2 presents the categorization of n-gain characteristics within the conditional and control group.

Table 2. Participant Classification Considering N-Gain Mathematics Problem Solving

Category	Enhancement Category	Total Subject	n-gain Mean	Percent (%)
Eksperimental	High	5	0.77	26.32
	Medium	14	0.53	73.68
	Low	-	-	-
Control	High	-	-	-
	Medium	2	0.73	11.76
	Low	12	0.48	70.59

In the opinion of Hake (1999), the aforementioned classification is based on the n-gain parameters. According to the previously provided table 2, the greatest n-gain percentages tends to be in the medium range for the control class and the largest category for the experimental class. There are no students in the high grouping with a low n-gain category. Students in control classes do not fall into the group of high advancement. The testing group and the control group differed in the proportion of medium gain requirements by 0.2 and 16.92 percentage points, respectively. This demonstrates that, in comparison to control learning, experiments are more effective at enhancing the abilities of learners to solve problems.

Furthermore, statistical tests will be carried out on the pretest, posttest and n-gain data for the experimental class and conventional class to obtain answers to the problem formulation. The average difference test in the pretest aims to see whether the problem solving abilities of students in the experimental and conventional classes are not significantly different. The posttest mean difference test aims to see whether the final problem solving abilities of students in the experimental class are significantly better than those in the control class. Meanwhile, the n-gain average difference test aims to answer the hypothesis "the increase in problem solving abilities of students who receive experiments is significantly better than students who receive conventional learning. In order to find out whether the statistical test used is parametric or non-parametric, the data is first tested for normality and homogeneity.

Normality Test

The Shapiro-Wilk test is the form of computed normalcy diagnostic that is employed. The conclusions of the normality analysis for the preliminary examination, posttest, and n-gain values are displayed in the following table.

Tabel 3. Normality Examine Result for Pretest, Postest, and N-Gain Scores for Mathematical Capacity to Solve Problems

Group		Shapiro Wilk analysis			
		Statistik	Df	Significant	H_0
Pretest	Exsperimental	0.154	19	0.200	Accepted
	Conventional	0.113	17	0.200	Accepted
Postest	Exsperimental	0.153	19	0.200	Accepted
	Conventional	0.158	17	0.200	Accepted
N-Gain	Exsperimental	0.212	19	0.122	Accepted
	Conventional	0.161	17	0.201	Accepted

The information in table 3 demonstrates that the study group's scores from both tests have a normality check result of 0.200, whereas the usual class's results are 0.200, both of which have a Significan ratio greater than α = 0.05. This indicates that both in experimental and control classrooms, the pretest and posttest results for students' aptitude for solving inquiries in mathematics significant statically from normal distribution follow a normal distribution. When the n-gain achieve dispersion is tested for normality, the outcome results indicate that both the experimental and regular classes' n-gain levels have Sig. values of 0.122 and 0.201, respectively, surpassing 0.05. This suggests that the n-gain scores are regularly distributed. A homogeneity of variance test was performed since no classes in the test did not have a normal distribution. Each of the average n-gain values were tested for differences.

Homogeneity Test

Apply the assessment Levene at a statistically significant degree of alpha equal to 0.05 with the aid of the SPSS twenty-five application to assess the justify of variance of the pretest, posttest, and n-gain ratings. The Table 4 listed below provides an overview of the calculations for the homogeneity analysis.

Table 4. Test for Homegenity of Variation

	Class	**Levene Test**			
		df1	df2	Sig.	H_0
Pretest	Exsperimental	1	34	0.223	Accepted
	Conventional				
Postest	Exsperimental	1	34	0.096	Accepted
	Conventional				
N-Gain	Exsperimental	1	34	0.119	Accepted
	Conventional				

It is evident from the data presented in table 4 over that the n-gain, pretest testing, and posttest results scores for mathematical problem solving abilities have Sig. greater than α = 0.05. It was concluded that the pretest, postest, and n-gain scores of mathematical problem-solving ability of experimental and conventional class students had significantly the same population variance.

Mean Difference Test

Due to the fact that both divisions' pretest results reflect an identical variation in populations and are regularly spread. Therefore, a statistical procedure called the t-test, for short, was used to determine the significance of variations in beginning rankings for solving problems with mathematics abilities.

Table 5. Evaluate Findings for Variations in the Mean Pretest Results for Mathematical Solutions Capabilities

		t-analysis for Equality of Average				
		T	Df	Sig (two tailed)	Average Difference	Standard Error Difference
Gain	Based on that variances are equal.	-0.886	34	0.37	-1.32508	1.49499

The overall aptitude for mathematics of early learning pupils in experiments and the general mathematical solving issues competence among control group participants is not significantly different, as the significance level two-tailed of $0.37 > \alpha = 0.05$. Both categories' outcomes following the posttest have the same population variance and are regularly gave away. A test called the t test was used to determine the significance of the difference between the test group's and the control class's ultimate outcomes on solving mathematical issues abilities.

Table 6. Evaluate Findings for Variations in Mean Posttest Performance

		t-test for Equality of Means				
		T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Gain	Equal variances assumed	2.497	34	0.018	0.72727	062435

As may be shown, the result of the posttest yielded a two tailed Sig number of 0.018. Sig appreciate divided in half therefore 0.018 equals 0.009 less than 0.05 indicates that those enrolled in the experimental learning environment are much more adept at resolving problems in mathematics compared participants in the control group.

Hypothesis test:

Pupils who got experimentation outperformed pupils who underwent regular instruction in terms of growth in their ability to solve problems with mathematics.

Table 7. Outcomes derived from the N-Gain Rating Mean Differences Testing

		t-analysis for Equality of Averages				
		T	Df	Significant two tailed	Mean Difference	Standar Error Difference
Gain	Equal variances assumed	2.826	34	0.008	0.14015	0.04915

After assessing the n-gain results, the two-tailed significance threshold was 0.008, but fifty percent of 0.008 equals $0.004 < \alpha = 0.05$. It is found that following learning, pupils in the experimental group greatly outperform those in the standard classroom in terms of their average growth in their ability to solve mathematical problems. The purpose of this study is to enhance students' ability to solve mathematical inquiries by using instructional films.

The study's goal is to improve students' capacity to answer mathematical problems by using video learning. The ADDIE method was used to create the video. Video learning can assist students who have difficulties visualizing three-dimensional coordinate systems in space analytical geometry courses. The findings of this study reveal that students who learn using video learning have increased their mathematics problem solving skill when compared to students who do not learn using video.

A summary of the findings of a study on the implementation of a three-dimensional coordinate learning system related to students' ability to solve mathematical problems by using four indicators of problem-solving ability with five questions, the students' initial abilities in experimental and control classes do not differ significantly. Based on this image, it is possible to conclude that problem-solving capacity improves following treatment. The progress is seen not only in one perspective, but in all views utilized as a measure of problem-solving abilities.

This is consistent with Ramadhani & Silitonga (2023) study on ball material in the space analytical geometry class, which found that students who used video learning with a tablet pen improved their learning outcomes significantly. According to Dirgantoro et al., (2021), the usage of video learning improves students' capacity to answer mathematical problems when studying integral calculus.

CONCLUSION

Regarding the research's conclusion, students who acquire learning with video learning on the material of three-dimensional coordinate systems in the course of analytical geometry of space perform better than students who acquire conventional learning in singular. Furthermore, this study makes several recommendations, such as undertaking more detailed research, such as explaining n-gain in each problem-solving skill in depth, indicating which indicators have increased the most and which have not increased, and relating to previous research. The following idea is that video learning can be employed as one of the learning alternatives for studying three-dimensional coordinate systems in the course of analytical geometry of space. It is anticipated that the learning video content will be developed not only for the third-dimension coordinate system, but also for all of the materials in the analytic geometric space courses.

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