**MATHEMATICAL PROBLEMING ABILITY THROUGH DEVELOPMENT VIDEO TUTORIAL OF THREE DIMENSION COORDINATE SYSTEM LEARNING IN SPATIAL ANALYTIC GEOMETRY**

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**ABSTRACT**

 Because students are having trouble picturing the three-dimensional system of coordinates in the space analysis of geometry course, pupils' mathematical problem solving abilities is still low. Learning movies that aid in visualization are essential for pupils. The study at hand uses a design consisting of a pretest-posttest control group and is quasi-experimental in nature. While the control class experienced conventional teaching, the learners in the experimental group learned using three-dimensional in form coordinate system audiovisual media. A test of one's capacity to solve mathematical problems is 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 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 three-dimensional coordinate system.

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

**INTRODUCTION**

According to the National Council of Teachers of Mathematics, in order 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 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. If students have high reasoning abilities, they will see various ideas from various situations or problems experienced, while students who have low reasoning abilities will encounter various obstacles because they are unable to relate various facts to make conclusions to overcome problems (Kurnia 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. The benefit of representation is that it is a basic construction for understanding and utilizing this understanding to solve problems (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. (Andriani & Kristanto, 2020) (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. (Naila Muna & Wardhana, 2022)(Tesalonika et al., 2022)(Andriani & Kristanto, 2020)(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.

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**

1. **Mathematical Problem Solving Ability**

 Ilmiyah & Fitri (2020) explained that problem solving is very important because it is essential and fundamental so that students have a good understanding so they are able to solve complex and non-routine problems. Problem solving is the process of applying previously owned knowledge to new, unknown situations so that it is related to knowledge of the substance of the problem being faced. Students can solve problems by first understanding the problem, creating or creating a solution strategy, applying it to solve the problem and checking again the results of the work done.

 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).

1. **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. 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).

1. **Video Pembelajaran Sistem Koordinat Dimensi Tiga**

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, 2021). 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. 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 (Jamaliyah & Ferry Wulandari, 2022).

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. 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. 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.

**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.

preliminary test 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.

|  |  |  |
| --- | --- | --- |
|   | Conventional Class | Exsperimental Class |
| n | $$\overbar{x}$$ | $$s$$ | $$x\_{min}$$ | $$x\_{maks}$$ | n | $$\overbar{x}$$ | $$s$$ | $$x\_{min}$$ | $$x\_{maks}$$ |
| 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 | 0,40 | 0,81 |
| Ideal Maximum Scores : 100 |

 **Table 1. Descriptive Statistics of Mathematics Promblem Solving compentency Scores**

The data presented in table one 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 ordinary 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.

 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 regular classes received an n-gain score of zero. This indicates that following the completion of learning activities, both experimental and conventional, all students saw a rise in their results. The following table presents the categorization of n-gain characteristics within the conditional  and conventional group

**Table 2. Participant Classification Considering n-Gain Mathematics Problem Solving**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Category | Enhancement Category | Total Subject | Mean | Percent (%) |
| *Eksperimental* | High | 5 | 0,77 | 26,32 |
| Medium | 14 | 0,53 | 73,68 |
| Low | - | - | - |
| Conventional | 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, the greatest n-gain percentages tends to be in the medium range for the conventional 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 conventional classes do not fall into the group of high advancement. The testing group and the conventional group differed in the proportion of medium gain requirements by 0.2 and 16.92 percentage points, respectively. This demonstrates that, in comparison to traditional 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 conventional 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 | H0 |
| 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 three 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 Sig ratio greater than 0.05. This indicates that both in experimental and traditional classrooms, the pretest and posttest results for students' aptitude for solving inquiries in mathematics 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-four application to assess the homogeneous of variance of the baseline, posttest, and n-gain ratings. The fourth table 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. | H0 |
| **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, preliminary testing, and posttest results scores for mathematical problem solving abilities have Sig. greater than 0.05. It was determined that there was equal variation among individuals in the pretest, posttest, with n-gain grades for the mathematics problem-solving skills among students in the experimental setting and the normal group.

**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 preliminary test 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 traditional group participants do not vary substantially, as the significance level Two-tailed of 0.37 is over 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 normative 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 | 0,62435 |

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 traditional 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 is not equal to 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 ADDIE technique was used in the development of the video.In spatial analytical geometry classes, the use of instructional movies can aid learners whom struggle with visualization in understanding three dimensional in form coordinate schemes. The study's findings demonstrate that students who watch instructional videos during their studies have a greater gain in their capacity to solve mathematical puzzles than students who do not. This is consistent with study on ball substance in courses on spatial the field of analytical geometry whereby individuals' results for learning were improved when they engaged instructional movies with stylus pad assistance. According to investigations conducted by Dirgantoro et al., (2021), using instructional videos can truly help students master integral calculus more efficiently by improving their ability to solve mathematical problems.

**CONCLUSION**

The study's findings indicate that pupils who learned with video lessons on multifaceted system of coordinates content within a geographical analytical geometry course significantly outperformed those who received regular instruction in their growth as mathematical problem solvers. Furthermore, a recommendation from this present investigation is that learning using videos can be used as an alternative learning that can be applied in studying three-dimensional coordinate systems in spatial analytical geometry courses. It is hoped that the learning video material can be developed not only on three-dimensional coordinate systems but also for all material in the spatial analytical geometry course.

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