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Achievement of Students' Mathematical Understanding Through ICT-Assisted Analytical Geometry Learning

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Abstract: Analytical geometry is a crucial component of the curriculum for prospective mathematics teacher education, as it serves as a foundational skill for teaching in schools. However, recent studies have revealed that some students possess a limited comprehension of analytical geometry. In the current era, characterized by rapid technological advancement, there is an imperative for innovation in the pedagogy of analytical geometry, including the integration of ICT. This study aims to describe ICT-assisted analytical geometry learning and learning outcomes in the form of students' mathematical understanding achievements. The present study employs a mixed methods approach, integrating a sequential explanatory design. The quantitative research design employed is descriptive in nature, as it aims to articulate the students' mathematical understanding. To enhance the comprehension of the quantitative findings, qualitative research was conducted employing a holistic case study design, enabling a more profound examination of the data by incorporating students' perspectives and interpretations. The population of this study comprised second-semester prospective teacher students in classes A and B who had enrolled in analytical geometry courses at a university in Bandung City, Indonesia. The sample of this study was selected by purposive sampling, namely class A with a total of 40 students (12 males and 28 females). The study's findings suggest that the incorporation of ICT, specifically GeoGebra software and e-learning, enhances the effectiveness of learning analytical geometry, particularly the plane geometry topic. This enhancement is evident in the students' achievement in terms of mathematical understanding, which is satisfactory. Consequently, it is imperative to extend the application of ICT to other subjects or instructional segments.

Keywords: ICT, geogebra, analytical geometry.

▪ INTRODUCTION

Mathematics plays an important role in learning in school. This is because mathematics is an applied science that will always be found in daily life (Fitriani & Pujiastuti, 2021; Lea et al., 2022; Suswigi & Zanthy, 2019). There are three main areas of mathematics algebra, analysis, and geometry. However, there is also the opinion that mathematics can be divided into four main parts, namely algebra, arithmetic, geometry, and analysis (Rahmah, 2013). In geometry, there is a branch of science, one of which is analytical geometry which is a course that must be taken and mastered by all prospective teacher students because it is one of the provisions for teaching in schools (Al Hadi, 2024).

The importance of analytical geometry lies in its wide application in various fields such as physics, engineering, computer science, and many others. First, in mathematics analytic geometry plays an important role in mathematics by providing a bridge between algebra and geometry, thus studying geometric shapes using equations and coordinates. By representing geometric shapes as equations, analytic geometry simplifies geometric problems using algebraic techniques. Second, in physics, analytical geometry is used to describe the motion of objects in space using coordinates and equations to model particle

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trajectories and study wave behavior. Third, in engineering, analytical geometry to design and analyze structures, machines, and systems. Using coordinates and equations, engineers can create 3D models of components, simulate the behavior of materials under different conditions, and optimize system performance. Fourth, in computer science, analytical geometry is used in computer graphics, image processing, and geometric modeling. By representing objects as mathematical equations, computer scientists can create realistic 3D graphics, manipulate digital images, and design virtual environments. In addition, geometry is related to broader academic and career opportunities, as well as being one of the critical filters for entry into higher education programs and the world of work, as mentioned in the study by Aboagye et al. (Aboagye et al., 2021). With a good understanding of analytical geometry, students can develop mathematical skills that are essential for a wide range of fields of study and careers.

There are still mistakes made by students in solving topics in geometry, for example in the topic of line equations (Marits & Sudihartinih, 2022), or points and lines on the field (Sudihartinih, 2018). Students often make mistakes in solving geometry problems due to conceptual errors, calculation errors, and lack of precision, caused by haste in working on the problem (Listiani et al., 2019), lack of understanding of geometry concepts, rarely practicing geometry problems, and confusion when solving problems (Radiusman & Simanjuntak, 2021). These errors can be caused by factors such as low comprehension of subjects, especially in online learning environments during difficult times such as the COVID-19 pandemic (Masfingatin et al., 2021). Failure to do geometry assignments, among other things, is caused by a low ability to understand or grasp the meaning of the teaching materials learned.

Henceforth, the ability in question is referred to as the ability to understand mathematics. Mathematical understanding is a very important component because it results in the cognitive structure of students that the material they learn must be meaningful so that they can understand concepts well (Ginting & Sutirna, 2021; Rosida & Pujiastuti, 2020; Wijaya, Dewi, Fauziah, & Afrilianto, 2018). Good mathematical understanding will help students to solve mathematical problems (Lea et al., 2022; Nurdiyana, Pujiastuti, & Anriani, 2022; Yani, Maimunah, Roza, Murni, & Daim, 2019). In addition, a good mathematical understanding can also be a foundation for thinking in solving various mathematical problems and problems in life (Agustin & Yuliastuti, 2019). Mathematical comprehension skills can support the development of other mathematical skills, such as communication skills, problem-solving skills, reasoning, connection, representation, critical thinking, and creativity (Lea et al., 2022; Rochim, Herawati, & Nurwiani, 2021). Therefore, there is a need to make efforts to improve mathematical comprehension skills, especially for students who teach analytical geometry courses.

These improvement efforts can be done by using ICT in the form of GeoGebra in learning. A study is known that has succeeded in improving student learning outcomes on the concept of fields and lines in space by using GeoGebra assisted by e-learning (Sudihartinih & Wahyudin, 2019). GeoGebra helps students visualize and understand complex mathematical concepts through dynamic and interactive visual representations (Dildabayeva & Zhaydakbayeva, 2024; Ndagijimana et al., 2024; Putra et al., 2021; Yerizon, 2021). GeoGebra offers a useful opportunity to design interactive online learning that allows students to explore math more (Rochim et al., 2021). GeoGebra can also improve students' mathematical abstraction skills, motivation, and independence in learning analytical geometry (Ertekin, 2014; Kholid et al., 2022; Murtianto et al., 2019). Research has shown that GeoGebra has a positive impact on mathematical reasoning abilities (Carriazo-Regino et al., 2024; Tasman & Widjaja, 2023) and problem-solving skills (Septian, 2020). In addition to the media used, the learning model is also a success factor for students learning geometry. The learning model that can facilitate students to learn geometry to increase the level of geometry thinking is the learning of the van Hiele model. This model has been developed by van Hiele where there are several steps, namely information (identifying students' understanding), guided orientation (students exploring an object), explicitation (explaining in their language), free orientation (solving open problems), and integration, which is integrating the objects that have been studied (Armah et al., 2018).

The results of previous research related to mathematical understanding, geometry learning, and learning media, show that there are still mistakes in students in terms of solving line equations (Marits & Sudihartinih, 2022), Students' ability to represent a mathematical problems into other forms of representation is not optimal (Ikashaum, Mustika, Wulantina, & Cahyo, 2021; Pamungkas & Sudihartinih, 2021). Based on this description, no research has been found on ICT-assisted analytical geometry learning in achieving students' mathematical understanding of field geometry topics. Therefore, the purpose of this study is to describe the learning of ICT-assisted analytical geometry and the achievement of students' mathematical understanding at one of the universities in the city of Bandung. The research questions are as follows:

1. How is the description of analytical geometry learning assisted by ICT?
2. How is the description of students' understanding of analytical geometry after ICT-assisted lectures?
3. How are students' responses to analytical geometry learning assisted by ICT?

▪ METHOD

Research Design

This study uses a mixed methods approach with a sequential explanatory design . The quantitative research design used is descriptive quantitative research because it describes students' mathematical understanding. Quantitative data in the study was obtained from the results of geometry tests of students who had received ICT-assisted analytical geometry learning. Furthermore, to have a better understanding of the results of quantitative data, qualitative data is collected so that it can provide a more in-depth analysis of the data by considering students' ideas and perceptions with their statements. Therefore, it is continued with a holistic type case study design, which is to describe various field findings (Yin, 2009). Content analysis procedures for qualitative data are collected to conduct interpretive investigations. The theme for the data collected in this study was mainly based on the literature. Furthermore, the theme is categorized and concluded. In addition, qualitative data can provide a basis that will complement, expand, or explain quantitative data (John W. Cresswell, 2014). Figure 1 below is a chart of this research design.

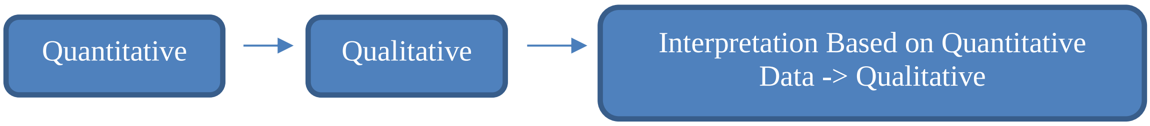

Figure 1. Research design

Research Place and Subject

The place of this research is the Mathematics Education Study Program of the Department of Mathematics Education at one of the universities in the city of Bandung. The population of this study is all active students in the Department of Mathematics Education who are participating in analytical geometry learning for the 2022/2023 academic year. Where the students are placed in both classes, namely class A and class B randomly by the university so that the conclusions obtained in this study apply not only to the research sample but also to the research population.

The selection of the subject of this research is purposive sampling where the author is assigned by the leadership of the Department of Mathematics Education to provide analytical geometry learning in class A. Therefore, the subject of this research consists of a class of second-semester students who take part in analytical geometry learning consisting of 40 people (consisting of 12 males and 28 females). Where the student has just taken part in Basic Mathematics and Number Theory so he has not taken part in other mathematics learning.

Data Collection Instruments and Techniques

The data collection techniques used in this study are tests, questionnaires, interviews, and documentation. The test used is a subjective/descriptive mathematical comprehension test. This is intended so that students' mathematical comprehension abilities can be seen from each completion step used. The questionnaire is in the form of open-ended questions on ICT-assisted analytical geometry learning. Interviews were conducted with several people taken from the sample using purposive sampling techniques to find out more about the completion of the previous test. The documentation in this study is in the form of photos, videos, and notes obtained during the implementation of classroom learning.

The instrumen ts in this study are mathematical comprehension test sheets, response questionnaires, interview guidelines, and tools for documentation. The mathematical comprehension test sheet in the form of a description consists of eight questions that have been validated by a mathematics lecturer. Where the questions are designed based on the lecture material, namely the coordinate system (questions 1, 2, and 3), lines (questions 4, 5, and 6), and conic sections (questions 7 and 8). The test was carried out during the mid-semester exam, which was the 8th meeting. Furthermore, the test results are assessed by the teaching lecturer using the assessment rubric. The following are the questions given.

1. It is known that an equilateral triangle has two angular points, namely O(0,0) and $A\left(\frac{1}{2}a, 0\right)$ with a<0. Where is the third angular point of the triangle located? Explain!

2. Known point $A(3{,}6), B(7{,}3)$, and C(x,y) Cholinear. Look for the coordinates $C(x, y)$ if $|AC| = \frac{1}{2}|AB|$
3. Known triangles with angular points $A(-4{,}2), B(-7{,}0), C(-2, -2)$. Determine the equation of the high line passing through A on BC.
4. Determine the equation of the lines formed by the intersection of two lines $3x - y = -3$ and $-3x - 2y = 12$ through the point (7,1).
5. Determine the equation of the line passing through $(-2, -2)$ and form a triangle with a coordinate axis and an area of 8 units.
6. Define a simple equation and a parabolic sketch that passes through a point (2,4).
7. Determine the simple equation of ellipses with b=4, Length of the latus rectum 6, and focus on the x-axis.
8. Determine one of the simple equations of hyperbolic if through (3,8) and the difference in focal distance is 6.

Furthermore, the interview instrument was prepared to elaborate on several topics including (1) students' understanding of geometry concepts; and (2) the benefits felt by students when using GeoGebra-assisted e-learning in the learning process. Based on the results of the instrument trial on 40 prospective teacher student participants and analysis assisted by Winstep software, it is known that the test instrument is categorized as fit with a question reliability of 0.96, including the excellent category. With easy question number 4, medium questions numbers 3, 7, 1, 6, and 2, while difficult questions numbers 5 and 8. Thus, the test instrument can be used in research.

Data Analysis

To process quantitative data, the researcher used Microsoft Excel and Winstep software. The scores obtained from students' answers are processed statistically descriptively, so that averages, maximum scores, minimum scores, and standard deviations are obtained to determine the level of achievement of students' mathematical understanding in solving analytical geometry problems. Furthermore, qualitative data processing is carried out as follows.

Data Reduction

First, the results of the documentation study in the form of written documents, photos, and videos were grouped according to the needs of the research. Second, the data from the interview results in the form of answers from students was grouped to find out the data needed in the research. Third, the results of the student test are described according to the questions that have been written.

Data Presentation

The presentation of data used by the researcher is in the form of narrative text containing a description of the research findings. The description of the data is used to clarify the information that has been obtained by the researcher regarding the results of student tests.

Conclusion

This conclusion was drawn to answer the purpose of the research. In conclusion, researchers do it continuously while in the field. The conclusions obtained will then be verified to find out whether they are by the facts on the ground.

After data analysis, qualitative data validation is carried out following the rules of data validation in qualitative research, namely a constant comparison of the following three things. First, triangulation is by analyzing several different data sources (in the form of written tests, student response questionnaires, interviews, observations, and documentation) through the examination of evidence using these sources. Second, using member checking to study the results of the implementation, i.e. making final confirmations, or data descriptions to participants to provide an opportunity to comment on the accuracy of the data. Third, contextual completeness, which is using various references and previous research reports to produce the validity of information.

▪ RESULT AND DISSCUSSION

In this section, we discuss the learning experiments carried out, the analysis of learning outcome data, and the theoretical implications of the research results.

Learning with GeoGebra Assisted by E-learning

The learning design with GeoGebra assisted by e-learning includes introductory, core, and closing activities. The preliminary activity consisted of reading prayers, checking student attendance, providing an overview of the importance of learning geometry, and conveying the learning objectives to be achieved.

The core activity consists of 5 phases, namely phase 1) Information, through discussion, educators identify students' understanding of a topic and students become oriented to new topics. 2) Guided orientation in which the student explores an object in structured tasks chosen in such a way that the characteristic structure appears to him gradually. 3) Explanation, the experience gained is related to the appropriate linguistic symbols and students learn to express their opinions about the structures observed during discussions in class. 4) Free orientation, i.e. students apply the relationships between the objects they are studying to solve problems and investigate more open-ended tasks. 5) Integration, where students summarize and integrate the objects they have learned, and become new knowledge.

The following is an example of the design of teaching materials, which includes students being asked to solve problems about the equation of lines that are perpendicular to the line $2x+7y+5=0$ and through $(2,-1)$. So the solution is that students can determine the line $2x+7y+5=0$ and the point $(2,-1)$ on GeoGebra. Next, make a perpendicular line to the line and place it at point $(2,-1)$, then the line passes through point $(2,-1)$ and is perpendicular to the line $2x+7y+5=0$ with the equation $7x-2y-16=0$.

After the lecture is over, students are asked to convey the conclusion of what has been learned at the meeting. In addition, lecturers also upload teaching materials and assignments that must be done by students into e-learning, namely SPADA. The following is an example of e-learning content shown in Figure 2.

Based on the results of lecturer observations conducted by the researcher himself, it is known that students are enthusiastic about using GeoGebra. This happens because students are helped by the visualization in GeoGebra. Collection through SPADA also trains students to be responsible and disciplined about the time of assignment collection. However, there is a challenge, namely the need for ideas from lecturers to design appropriate assignments to be explored through GeoGebra. And the need for lecturers to have more time to fill in lecture content and correct student assignments in SPADA.

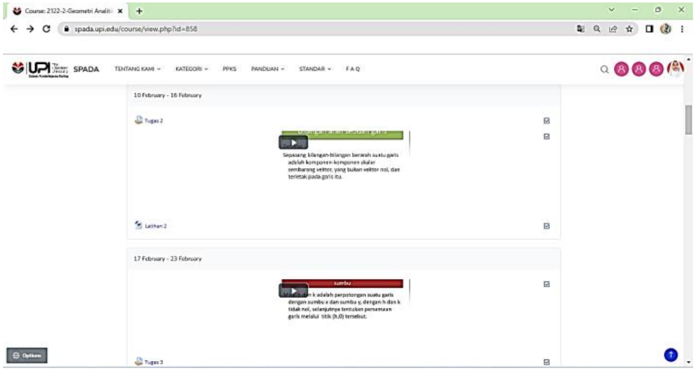

Figure 2. Examples of e-learning content

Student Learning Outcomes

After the learning process, to evaluate the achievement of students' mathematical comprehension skills, a test is carried out in the middle of the semester. The following is the documentation of the test implementation in Figure 3. Furthermore, the results of the student test are compiled in Table 1, as follows.

Figure 3. Test execution

Table 1. Total student score

Total Score	Student	The Number of Students
0 – 20	P05. P07. P12. P14. P35. P39	6
20.01 – 40	P01. P02. P04. P08. P09. P13. P16. P22. P24. P25. P26. P27. P29. P37. P40	15
40.01 – 60	P03. P06. P10. P11. P15. P17. P18. P19. P20. P21. P23. P28. P30. P31. P32. P34. P36. P38	18
60.01 – 80	P33	1

Table 1 shows that some students understand the material related to analytical geometry because more than 50% of students have scores above 40. The data in the table is then arranged in a diagram, as shown in Figure 4 below.

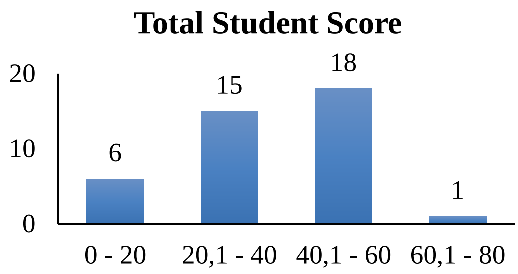

Figure 4. Student total score chart

Furthermore, in Figure 5, the student's understanding of each topic will be shown, which is represented by the question number. The question with the largest average is question number 4 with an average of 7.03 (easy question criteria). The lowest average is in question number 8, which is 1.38 (difficult question criteria).

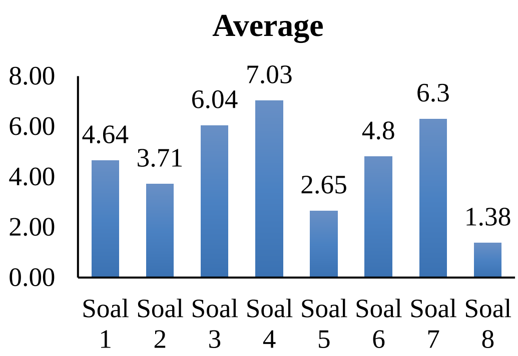

Figure 5. Average diagram of each question

The next information obtained is that in each question, students can achieve a score with a high score. The highest score obtained by students on questions 3 to 7 is 10. This shows that there are students who can work on problems well after learning ICT-assisted geometry. The test results also obtained information on the minimum score obtained by students. The smallest score obtained on each question is 0. This shows that there are students who do not understand each of these questions. However, the number of students who got a score of 0 was only 18.75% compared to the overall average score.

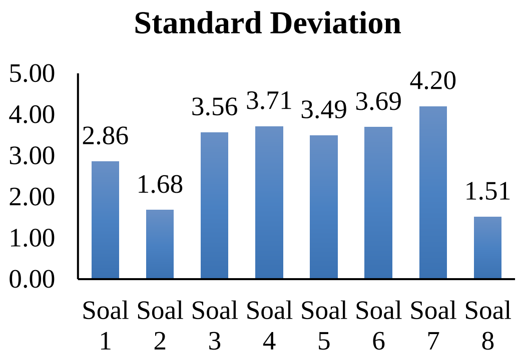

Figure 6. Standard deviation chart of each question

Furthermore, to show the heterogeneity of the data, it is calculated using the standard deviation value. The question with the highest standard deviation is question number 7 with a standard deviation of 4.20. Meanwhile, the one with the lowest standard deviation is question number 8 with a standard deviation of 1.51. Furthermore, to observe the standard deviation of each question is shown in Figure 6.

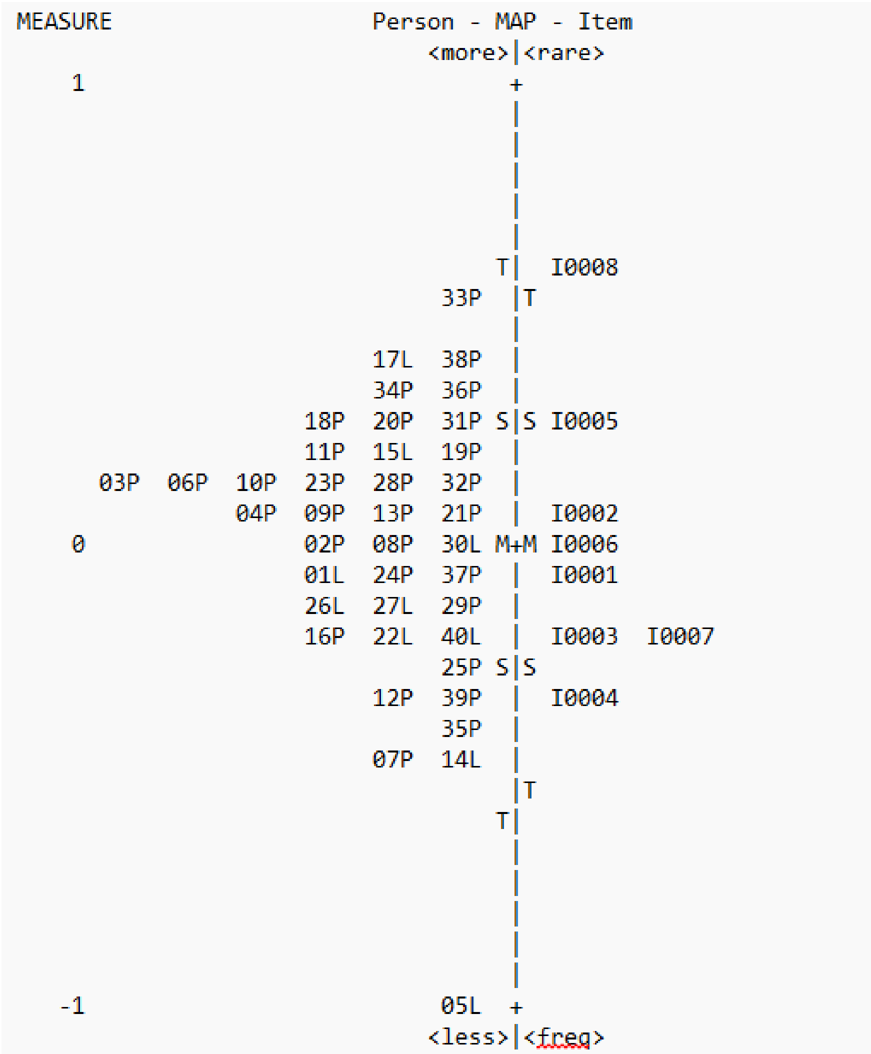

Figure 7. Person-map-item

Based on Figure 7, it is known that almost all students can solve question number 4 except for participants 07P, 14L, and 35 P. Participant 33P gets the highest score. No participants answered question number 8 correctly. However, more than half of the participants got above average scores.

In Figure 8, it is known that all students answered the test questions considered fit according to the criteria of Boone et al. (Boone et al., 2014). That is, they meet one of the following three criteria. First, the MNSQ outfit value is greater than 0.5 and less than 1.5. Second, the ZSTD outfit value is greater than -2.0 and less than 2.0. Third, the PT Measure Corr value is more than 0.4 and less than 0.85.

Person STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Person
33	59	8	.54	.18	.64	-.45	.52	-.36	.71	.60	12.5	16.4	33P
17	54	8	.40	.16	1.38	.80	1.07	.33	.52	.63	.0	7.1	17L
38	54	8	.40	.16	.72	-.38	.57	-.49	.79	.63	12.5	7.1	38P
34	52	8	.35	.15	1.53	1.04	1.25	.57	.59	.63	.0	9.5	34P
36	51	8	.33	.15	1.67	1.25	1.35	.71	.51	.63	12.5	9.4	36P
31	48	8	.26	.14	.84	-.19	.68	-.46	.82	.63	12.5	9.4	31P
18	47	8	.24	.14	.21	-2.46	.22	-2.00	.93	.62	25.0	10.6	18P
20	47	8	.24	.14	.54	-1.04	.51	-.93	.71	.62	50.0	10.6	20P
11	45	8	.20	.14	.29	-2.08	.30	-1.76	.89	.62	25.0	10.0	11P
15	44	8	.18	.14	.84	-.24	.85	-.14	.55	.61	12.5	10.0	15L
19	44	8	.18	.14	.82	-.30	.72	-.44	.78	.61	12.5	10.0	19P
3	42	8	.15	.14	.46	-1.46	.47	-1.21	.86	.60	37.5	11.0	03P
10	42	8	.15	.14	.35	-1.94	.35	-1.65	.80	.60	37.5	11.0	10P
23	42	8	.15	.14	1.82	1.69	1.88	1.61	.03	.60	25.0	11.0	23P
28	42	8	.15	.14	.36	-1.85	.38	-1.54	.86	.60	37.5	11.0	28P
6	40	8	.11	.14	.95	.02	.92	-.01	.31	.59	12.5	9.0	06P
32	40	8	.11	.14	.62	-.91	.65	-.69	.90	.59	12.5	9.0	32P
4	39	8	.09	.13	.98	.10	.95	.05	.72	.59	25.0	10.1	04P
21	39	8	.09	.13	.97	.06	.90	-.05	.65	.59	.0	10.1	21P
13	38	8	.07	.13	.33	-2.09	.37	-1.63	.86	.58	37.5	10.0	13P
9	37	8	.06	.13	2.14	2.26	2.27	2.15	.31	.58	12.5	12.3	09P
2	33	8	-.02	.13	1.23	.66	1.22	.58	.50	.55	.0	11.5	02P
8	33	8	-.02	.13	1.46	1.12	1.45	.98	.31	.55	12.5	11.5	08P
30	29	7	-.02	.15	.67	-.70	.60	-.72	.71	.58	.0	11.2	30L
1	32	8	-.04	.13	1.29	.79	1.17	.49	.62	.54	12.5	12.5	01L
37	31	8	-.05	.14	.83	-.30	.79	-.30	.73	.54	12.5	13.5	37P
24	30	8	-.07	.14	.78	-.42	.74	-.40	.48	.53	.0	13.5	24P
29	28	8	-.11	.14	.82	-.31	.78	-.29	.73	.51	.0	12.9	29P
27	27	8	-.13	.14	2.36	2.44	3.11	2.81	-.13	.50	12.5	12.8	27L
26	26	8	-.15	.14	.83	-.25	.87	-.07	.60	.50	.0	14.3	26L
16	25	8	-.17	.14	1.78	1.55	1.48	.95	.48	.49	12.5	13.3	16P
22	24	8	-.19	.14	1.10	.37	.96	.11	.32	.48	.0	13.4	22L
40	23	8	-.21	.15	.89	-.09	.78	-.24	.51	.47	12.5	13.4	40L
25	21	8	-.25	.15	2.44	2.21	2.30	1.82	-.08	.45	.0	15.7	25P
39	19	8	-.30	.16	1.61	1.12	1.47	.87	.23	.43	12.5	16.7	39P
12	18	8	-.33	.16	.23	-1.86	.39	-1.05	.59	.42	37.5	16.7	12P
35	15	8	-.41	.18	.95	.14	1.13	.41	.34	.38	25.0	13.9	35P
7	14	8	-.45	.18	.56	-.56	1.84	1.19	-.30	.37	50.0	18.6	07P
14	13	8	-.48	.19	.76	-.15	.73	-.18	.50	.36	25.0	24.6	14L
5	5	8	-.98	.33	.97	.28	1.13	.45	.05	.23	50.0	36.8	05L
MEAN	34.8	8.0	.00	.15	1.00	-.1	1.00	.0			17.2	12.8	
P.SD	12.7	.2	.29	.03	.56	1.2	.60	1.1			15.0	5.0	

Figure 8. Person statistics

After the test was completed, interviews were conducted with 3 students regarding the written answers. The students interviewed are students with answers that are considered unique and can represent answers with the same criteria, namely P40, P19, and P29. The answers to the P40, P19, and P29 tests as seen in Figure 9.

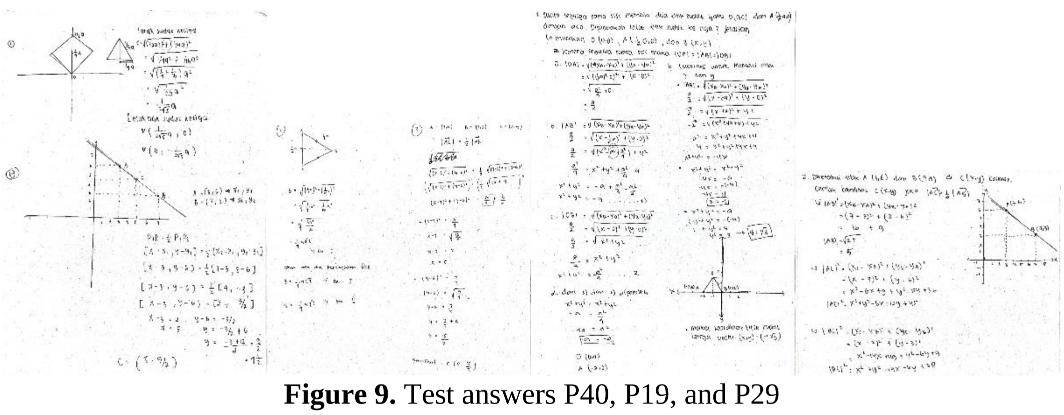

Figure 9. Test answers P40, P19, and P29

The following are the results of the interview conducted by the researcher (I) with P40 as a participant.

I : Please explain your answer number 1.

Q40 : But this seems to be wrong. This is an equilateral triangle and it is known to have 2 corner points, but this is the wrong image because it is a<0.

I : Yes, that's right, so before you were fooled by a negative value. Next, why use this method to find the third corner point?

P40 : Since the third angular point will be perpendicular to the midpoints A and B, it uses the Pythagorean formula. But this is wrong, it should be subtracted, not increased because what is sought is not the slash.

I : Okay. Furthermore, in number 2, why use the midpoint formula?

Q40 : Since the AC is half of AB it means that C is in the middle of AB.

I : From the problem, the length of the air conditioner is half the length of AB or equal to the length of AB is twice the length of the air conditioner. Your answer is correct C it can be right in the middle of AB, but it can also be that this point C is next to A, so the position is C-A-B.

Q40 : That means the point can be outside AB, right?

I : Yes, that's right, so the correct answer is that there are two possible points. Now what do you think when doing the learning process with the help of GeoGebra?

P40 : GeoGebra gives us a clearer picture of what we learn in analytical geometry in Cartesian coordinates, the tools in GeoGebra are complete so that we can check the results of our work in GeoGebra.

Based on the results of the interview, P40 understood the concept of working on question number 1, but the work was wrong because he remembered the formula wrongly. As for the number 2, P40 can find one of the possible answers with the help of pictures. Furthermore, the following are the results of the researcher's (I) interview with P19 as a participant.

I : Please explain the answer number 1.

P19 : Earlier, when I read it, I only focused on the point that was known, but the point a<0 was not read, so the point was located in quadrant I.

I : If the picture is a picture, why not use the coordinate axis?

Q19 : Because there is no command to describe it, so only the important thing is to draw the triangle.

I : Yes, I am not asked to describe it, but usually the picture can make it easier to work on the problem.

Q19 : Yes, it was written on a piece of paper.

I : This means that this is the answer in quadrants I and II, huh?

P19 : Well, yes, it is written in quadrants I and II, but it should be in quadrants II and III because a is negative.

I : Furthermore, what is the process of working on number 2?

Q19 : I remember the formula was the middle point, so I used that formula. But later the results will be paired between the summation in the left and right segments.

I : That's not right, because in the equation the result is not necessarily by the one on the right. So, the point C can be between AB or outside the segment of the AB line, which is near C.
Q19 : Oh yes, that's right, but when I was working on it, I didn't think to describe the line first.
I : Next, what do you think when doing the learning process with the help of GeoGebra?
Q19 : GeoGebra helps me to create and visualize the visual shapes of points, lines, and cone slices more easily and neatly.

Based on the results of the interview, P19 already knew the method that must be used to solve the two problems. However, P19 has not been able to solve the good problem number 1. This can happen because P19 does not describe what is known in the question. Finally, the following are the results of the researcher's (I) interview with P29 as a participant.

I : Please explain the answer number 1.
P29 : Initially, I looked for A first with the formula for the distance from O to A, and the result was obtained. Then find the distance A to B and O to B using the same formula. a/2.
I : Is $\left(x - \frac{1}{2}a\right)^2$ Result $x^2 - a + \frac{a^2}{4}$
P29 : Yes. Oh, yes, I forgot to put it in, so I guess it should have been. x^2-ax+a^2/4.
A : Yes, so it is also wrong.
Q29 : Oh yes, I also remembered that the answer should still be the variable x, but this is not, I don't know where the error is, so just continue.
I : Then this is from the same workmanship, does it mean that the location of the third point is only 1 possibility?
Q29 : Oh yes, that's wrong because the result should be ±.
I : If number 2 is done, how does it work?
Q29 : Well, this is the number 2 mah ngasal. The formula for dealing with this problem is forgettable. If the picture looks like this, but confused about the placement of the C point.
I : This point C can be between AB or outside the segment of the line AB which is near C. To do this we can use the midpoint formula for the first possibility. For the second possibility, you can use the formula that (CA) $\vec{}$=1/2 (AB) $\vec{}$. Furthermore, what do you think when doing the learning process with the help of GeoGebra?
P29 : With GeoGebra, I have become more able to imagine how the points, lines, and slices of the cone are being studied in the analytical geometry course.

The images made by P29 can help P29 better understand the problems and expected solutions. However, in the process, several times P29 forgot the formula or was not correct in the number operation part. Furthermore, it is known that all students gave a positive response to GeoGebra so it was included in the category very well. In Table 2, there are examples of some student responses to GeoGebra.

Table 2. Student response to GeoGebra

Do you enjoy using GeoGebra?	What are the benefits of using GeoGebra?	What are the impressions and messages of using GeoGebra?
Agree	Learn more about how to use GeoGebra	The effect is, not bad.
Agree	Practice creativity and apply the math learning that has been learned	To check that there are no errors in any formula or action performed in GeoGebra
Yes	I can learn and explore GeoGebra	Very good and very helpful
Happy	I can explore what tools are in the GeoGebra application so that it will be new knowledge for me that can be used for other courses that require a GeoGebra application.	At first, I was a little confused because there are so many tools in GeoGebra, but after finding out more, I was able to understand it a little bit, and with that, I understood very well what I was doing.
Agree	Train and improve your ability to use GeoGebra	It's fun to work at GeoGebra because it tests the accuracy

Based on the research that has been conducted, learning Analytical Geometry using GeoGebra assisted by e-learning can help students understand concepts. This is reviewed from the students' achievement of the average score, standard deviation and maximum score of each question shows that students' understanding of analytical geometry, especially related to the topic of points in the field, is quite good. In addition, based on the analysis of the interview results, it shows that GeoGebra also provides several benefits that can help students in learning, including:

First, GeoGebra can help students develop mathematical intuition and visualize mathematical procedures (Dikovic, 2009). This is based on several student statements that learning through the GeoGebra application presents visualizations that can help students understand concepts well. In line with this, an effective digital learning media for mathematics learning is a medium that can arouse students' curiosity about the mathematical concepts they are learning (Putrawangsa & Hasanah, 2018). In this situation, using technology should not make students spared in the use of their mathematical intuition; Instead, using technology can help improve students' mathematical intuition skills.

Second, GeoGebra can help the development of students' conceptual thinking (Akkaya et al., 2011). This is shown by the ability of students to be able to improve conceptual knowledge of mathematical ideas through learning fields and lines in space by integrating GeoGebra software and e-learning. In line with this, Putrawangsa & Hasanah emphasized that there are three didactic functions of digital technology in mathematics learning, namely: (1) Technology for doing mathematics, which is technology that functions as an alternative tool for learning media to carry out mathematical activities; (2) Technology for practicing skills, which is technology that functions as a learning environment to hone certain mathematical skills; (3) Technology for developing conceptual understanding, which is digital technology that functions as a learning medium to develop students' conceptual understanding of certain mathematical concepts. The third didactic function, namely technology for developing conceptual understanding, is one of the most expected from the integration of digital technology in mathematics learning.

According to the findings of this study, another benefit of GeoGebra is that it is effective in helping students recognize mathematical objects quickly (Choi, 2010) so it can increase the effectiveness of the teaching and learning process (Trung, 2014; Fitriani & Pujiastuti, 2021). The availability of e-learning that allows students to benefit from the ease of learning at any time and from any location supports the effectiveness of GeoGebra (Glosary dalam Wahono, 2008). Thus, the findings of this study show that the use of e-learning is the right learning strategy for learning in the era of digital transformation (Rosenberg & Foshay, 2002).

▪ CONCLUSION

This study concludes that the use of GeoGebra software and e-learning is effectively used in analytical geometry learning, especially field geometry topics. This is reviewed based on the achievement of good student learning outcomes and various benefits that can be felt directly by students in the GeoGebra-assisted learning process. Therefore, the use of GeoGebra is expected to be applied to other geometric materials.

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