Application of geogebra software to improve problem-solving skills in analytic geometry in prospective teachers students

A I Sugandi and M Bernard
IKIP Siliwangi, Jl. Terusan Jenderal Sudirman, Cimahi 40526, Indonesia

Email: asepikinsugandi@ikipsiliwangi.ac.id

Abstract. This study aims to examine the improvement in thinking skills problem solving of prospective teacher students in learning analytic geometry using GeoGebra software. The population in this study were all students of IKIP Siliwangi, with a sample of class One class 2018 totalling 35 people. The instrument used in this study was a test in the form of a 5-item description question and a non-test in the form of a Likert scale. Based on the results of data processing, it can be concluded that the use of GeoGebra software is effective in improving problem-solving skills in analytic geometry learning. Overall, students' responses to the use of GeoGebra software in learning analytic geometry courses are in a very strong category. The highest indicator of student attitudes towards the use of GeoGebra software is achieved on the indicator of interest in the media and the indicator that has the lowest percentage lies in the indicator of image use.

1. Introduction
Analytic geometry is a branch of mathematics gained from the combination of algebra and geometry. By making correspondence between algebraic mathematical equations and geometric positions, a more systematic and firmer method of solving geometric problems is obtained. Geometry problems will be solved algebraically (or analytically). Instead, geometric drawings often provide a clearer understanding of the meaning of algebraic results only. In this case, it is also possible to solve the problem of algebraic geometry, but the geometric shape model is far more important than just solving, especially if numbers are associated with the basic concepts of geometry.

Analytic Geometry lectures are an essential part of learning mathematics in college. The concept of analytic geometry needs to be mastered by students correctly and adequately. This is due to analytic geometry being a prerequisite for learning other mathematical concepts such as algebra and Calculus. There are still many students who do not yet have a deep knowledge of analytic geometry concepts. This not only impacts the lack of creativity in solving problems in this material but also results in lower learning outcomes in this course. Students have difficulty in solving analytic geometry problems on material lines and circles. Specifically, the problem lies in the pressure of memorizing the formula used to solve a given problem. In addition, another obstacle is in determining the procedure for solving a given problem memorizing the formula used to work on a given problem and when determining the steps for working on a given problem and difficulty understanding the direction of the given problem [1].

In teaching analytic geometry material, lecturers need to use a learning medium that makes it easy and shortens the time for drawing and helps make changes that occur in geometry objects look clear and real. It aims to make learning more effective and efficient, as well as more time to explore geometric
objects. Finally, it can help students understand the geometry concept of transformation well and develop mathematical skills.

The use of inappropriate media learning can be a liaison for students to explore the material and improve and develop quality in learning [2]. Some of the benefits of using media in learning are that it can clarify the meaning of a material, not only is verbalist, learning can be more varied, active, interesting, and overcome the limitations of the dimensions of space [3]. The learning media has a liaison function that has the nature to bring up student attention (student interest) in the teaching and learning process and in achieving desired goals [4]. In the learning process the teacher is required to be able to plan the implementation of learning media properly because using media can concretize abstract things, can increase absorption, and help students understand things that are difficult to comprehend verbally [5].

One of the interactive media that can be used is GeoGebra. GeoGebra is a dynamic geometry software so that it can construct points, vectors, line segments, lines, conic sections, even functions, and change them dynamically [6]. With the use of learning media, GeoGebra is expected to facilitate teaching and learning activities in mathematics and make teaching and learning activities become interesting, active, and not monotonous. One of the considerations of using GeoGebra software is that it can encourage students to be actively involved in learning to improve their understanding of geometrical material [7].

Some of the advantages of GeoGebra are that it can describe something that happens if you change something else so that it can guide students to experiment freely in finding and developing solutions to problems. This program can also study geometrical and analytic problems in the algebraic form correctly and appropriately [8]. The use of GeoGebra in Analytical Geometry can make learning more effective and efficient. The flexibility of GeoGebra in facilitating various kinds of students' ideas and thoughts when solving the problem-solving problems in Analytic Geometry. Thus through the use of GeoGebra software, it is expected that the problem-solving ability of prospective teacher students in analytic geometry courses can be increased.

2. Method

This research is a quasi-experimental study, because of the manipulation of treatment and sampling is done on groups that have been made. The research design used is nonequivalent groups pretest-posttest design. This design was chosen because the researcher assumed that the subjects were not randomly grouped, but the researcher accepted the subject's condition as it was in this study there are also pretest, treatment, and posttest. The following is a one-group pretest-posttest research design (Pretest Treatment Posttest).

O X O
Information:
O: Pretest or Posttest
X: GeoGebra-based geometry learning.

The instrument in this study was in the form of a test in the form of 5 questions. The problem has fulfilled the requirements of good questions in terms of velocity, reliability, distinguishing features and difficulty index, while the non-test consists of 25 statements in the form of a Likert scale with 5 indicators of the application of GeoGebra software in learning analytic geometry courses, then the percentage is calculated.

3. Result and Discussion

3.1. The Learning Process completes the Analytic Geometry problem with Geogebra Software

The instrument in this study was in the form of a test in the form of 5 questions. The problem has fulfilled the requirements of good questions in terms of velocity, reliability, distinguishing features and difficulty index, while the non-test consists of 25 statements in the form of a Likert scale with 5 indicators of the
application of GeoGebra software in learning analytic geometry courses, then the percentage is calculated.

The results shown in the GeoGebra display encourage students to develop and explore deeper to master mathematical concepts in geometry that relate to real display images quickly by adjusting the accuracy of the position of the image. Students will understand the problem-solving problem after seeing the results made in writing according to the pictures made.

Consider the following example problem:

Given three points A (-5,1), B (-1,-1), and C (x, y), if it is known that the area of the triangle is equal to 11. Determine the position equation of the point!

![Figure 1. Explanation of Problem-Solving problem 1](image)

Explanation of Figure 1, explains the steps in problem-solving looking for a new line equation of known area with two different points. In the first step, the researcher provides basic knowledge about straight-line equations at the two points AB, using the formula of the equation of the line from two points, namely points A (-5.1) and B (-1,-1) so that the equation AB \( x + 2y = -3 \) using GeoGebra, the second step, students are given instructions related to the broad line drawing as a clue to the base AB using the two-point distance formula and the proof of the AB segment command. The third step, determine other measurements related to the area besides base and area, where students have determined the base of the triangle which is 4.47 units so that it is obtained from the height of the triangle from the formula area of the triangle \( 2 \times 11 / \sqrt{5} = 4.92 \) units, by determining the result of height means that the student is describing where the point is outside the AB line, the students suspect that there must be a perpendicular line from the baseline, the fourth step, to find the perpendicular line, the student first determines one of the arbitrary points but is in the AB line equation, for example, choosing point B (-1,-1), after that a perpendicular line is made by finding the gradient line AB, \( m_{\perp AB} = 2 \) and the AC line equation, \( y = 2x + 1 \) is obtained. The fifth step, make any point in the AC line equation such that point B and point C are adjusted to the length of height 4.92 and then adjusted to the student’s calculation by using the formula of the distance between two points and substitution y with x, and the result x = 1.2 and y = 3.4 which is an attribute of point position. In the sixth step, enter the point into the GeoGebra command by writing (1.2, 3.4), after that, it will be illustrated that the point is right on the GeoGebra screen. The seventh step, Make one more line from the GeoGebra command menu, which is Parallel line to point (1.2, 3.4) or point M, so that the equation \( x + 2y = 8 \) is obtained and then adjusted to the final settlement step carried out by students. In the eighth stage, re-evaluating whether the area of the triangle is 11, then the proof is using the GeoGebra command menu,
the Area and the results are by the expected statements so that the answers of students and proof of GeoGebra are correct.

Example Problem 2
Find the equation of the circle through A (3, -1), B (6,2) and C (5,3)

Figure 2. Explanation of Problem-Solving problem 2

Figure 2, how to explain how to determine the equation of a circle from the three known points. In the first step, the researchers entered the three points using the GeoGebra input commands namely (3, -1), (5,3), and (6,2) to bring up points A, B, and C on the GeoGebra screen. The second step, students are given a picture of a circle of three points and then observe from the picture and find 4 ways of observation, namely 1) simply determine 2 midpoints of each point, namely the midpoints of point A and point B, the midpoint of point B and point C; 2) enough to make 2 straight-line equations, namely AB line equation from point A to point B and straight-line equation BC from point B to point C; 3) after finding two straight-line equations, find the perpendicular line of the two straight-line equations through the midpoint; 4) determine the center point by eliminating and substituting the two perpendicular lines. The third step, after arranging the 4 observation methods, the researcher draws the connecting line connecting the Line menu at point A to point B and point B to point C and automatically displaying the description of the straight line AB function and the BC straight line equation and then observed by the student in exact accuracy. The calculation uses the equation of a straight line equation from two points. The third step, after the suitability of student workmanship and GeoGebra drawings, that the equation AB, \(-2x + y = -7\) and BC equation, \(-xy = -8\) then proceed to determine the position of the midpoint AB and the midpoint of BC by using the GeoGebra command menu namely Midpoint or center obtained point D (4,1) and point E (5.5,2.5) then adjusted to the results of the calculation method to find the midpoint. The fourth step, make a straight line that is perpendicular to AB through point D that is \(-x-2y = -6\) and the equation of the perpendicular line BC through point E which is \(xy = 3\) using the GeoGebra command menu that is Perpendicular Line and proven by calculation using the formula perpendicular line equation. The fourth step, make the intersection point with the GeoGebra menu that is Intersect of the two newly created equations so that F (4,1) is drawn as the center of the circle as expected before making a circle and proven using the substitution and elimination calculation method. The fifth step, draw a circle from point F to one of the three known points, for example, point A, then a circle image appears through the circle command menu, and is proven by calculating the formula of the circle equation with the center at point F and the radius with the length of the AF segment that is \((x-4)^2 + (y-1)^2 = 5\).

3.2. Test results for problem-solving in analytic geometry
Based on the data processing ability of problem-solving in analytic geometry, the results obtained are listed in Table 1
Table 1. Results of Problem-Solving Capabilities in Analytical Geometry Materials

| Problem solving skill | PRE TES | POS TES |
|-----------------------|---------|---------|
| \( \bar{x} \)       | 62.77   | 79.74   |
| s                    | 6.61    | 3.71    |

Henceforth, a normality test will be conducted on the pre and post-test results of the problem-solving ability. Based on the results of data processing the following results are obtained:

Table 2. Normality Test Results for Problem-Solving Capabilities

| Type of Test | Statistics | df | Sign |
|--------------|------------|----|------|
| Pos Tes      | 0.130      | 35 | 0.146 |
| Pre Tes      | 0.146      | 35 | 0.056 |

Based on Table 2, the sig value for the test post is 0.130 and the sig value for the control class is 0.146, because the sig value, both classes are greater than 0.05, it is concluded that the pre-test and post-test data are normally distributed. Henceforth, a t-test will be performed. Based on the results of data processing the following results are obtained:

Table 3. T Test Results for Problem-Solving Skills

| POS-PRE TEST | t     | df | Sign |
|--------------|-------|----|------|
|              | 13.86 | 34 | .000 |

Based on Table 3, it is found that sig. 0.00, because the sign value <0.05, it can be concluded that the improvement of problem-solving ability by using GeoGebra software in learning analytic geometry is significant

3.3. Questionnaire Processing Results

Based on the results of data processing on the questionnaire responses of students regarding the application of GeoGebra software in the eyes, analytic geometry obtained the Table 4.

Table 4. Percente Student Response Indicators

| No. | Indicator                              | Percentage | Criteria   |
|-----|----------------------------------------|------------|------------|
| 1.  | Use of Image                           | 75%        | Strong     |
| 2.  | Linkage of Material and Media Use      | 76%        | Strong     |
| 3.  | Interest in the media                  | 94%        | Very strong|
| 4.  | Satisfaction of the Media              | 85%        | Very strong|
| 5.  | Confidence                             | 84%        | Very strong|
|     | Total                                  | 83%        | Very strong|

Based on observations in analytic geometry learning that have been discussed in the research results obtained several things that can be stated include: learning using GeoGebra software math students can check the results quickly, this is by the opinion states that the use of software in learning can accelerate the completion of the teaching and learning process and can check the results of student work quickly and can learn various cases [9]. By immediately knowing the results of student work, students can immediately find errors or weaknesses in working on problems, so that students' mistakes in solving problems can be minimized, this is by the indicator a problem-solving that is seeing results again.

By learning to use GeoGebra software, students are required to solve problems in a variety of different ways so that this results in increasing their ability to think creatively. One alternative learning that can increase student creativity is learning using learning media, one of which is GeoGebra [10]. By increasing the ability to think creatively will also increase the ability of problem-solving, because creative thinking has a positive effect on a problem-solving. This is by opinion which states that there is a significant positive relationship between creativity with the ability to solve problems [11].

Learning by using GeoGebra software can change the geometry learning material that is originally abstracted to be concrete. The use of GeoGebra programs can visualize abstract geometry objects quickly, efficiently, and accurately [12]. With the change of the concept from an abstract to a concrete
one, the ability of students to understand the material being taught will increase. With the increased ability of understanding will also increase the ability of problem-solving because the understanding ability is positively correlated with problem-solving abilities [13].

Also, from observations, it was also found that the deepening of the material in the form of discussion and the use of the GeoGebra application would make it easier for students to think because using GeoGebra can draw geometry carefully and be able to show its properties, that applies to geometry. This is in line with the results based on interviews with students obtaining the results that GeoGebra makes it easy for students to discuss topics, allows them to communicate, work together and support learning understanding and get fast feedback [15]. The application of GeoGebra has a significant and positive effect on students, and increases student motivation, confidence, willingness to learn, and high-level mathematical thinking skills, one of which is problem-solving ability mathematical.

In learning by using GeoGebra software students are given flexibility in finding alternative solutions to problems. This is by the opinion states that the application of multimedia encourages students to be more flexible in finding the problem-solving process as desired [14]. With such conditions, students are expected to be able to improve their problem-solving abilities.

Based on the results of the processing of the questionnaire it was found that overall the indicator of student responses to the use of GeoGebra software in analytic geometry learning was 83% and it was categorized very strongly the attitude of students towards the use of GeoGebra in analytic geometry learning. The highest percentage is obtained on the indicator of interest in the media, while the lowest indicator is printed on the indicator of image use. In the Indicator of the use of pictures based on Table 7, the percentage of student responses obtained by 75% is in strong criteria. This is caused by GeoGebra software having advantages in animation and the existence of manipulation movements that encourage students to understand the concept of geometry [12].

In the Indicator of material linkage and media use based on Table 4, the percentage is 76% and it is in strong criteria. This is caused because GeoGebra software media can visualize what is abstract into concrete so that students can experiment freely in obtaining a solution to a problem. In the Indicator of interest in the media based on Table 4 a percentage of 94% is obtained with a very strong category. This is because learning using GeoGebra software is more interesting, adding active students in learning, so learning is not monotonous and varied [20]. In the Satisfaction Indicators of the media, based on Table 4, a percentage of 85% is obtained with a very strong category. This is because the learning experience gained by students using GeoGebra software gives a feeling of satisfaction and positive, with GeoGebra students get experience in visualizing abstract things to be concrete to provide provisions to learn further material. In the confidence indicator, based on Table 4 a percentage of 84% is obtained with a very strong category. This states that after learning analytic geometry material using GeoGebra software students have the confidence to be able to solve analytic geometry problems properly and correctly.

**4. Conclusion**

Based on the results of data processing, the following conclusions are obtained: the use of GeoGebra software is effective in improving problem-solving skills in analytic geometry learning, overall students' responses to the use of GeoGebra software in learning analytic geometry courses are in the very strong category. The highest indicator of student attitudes towards the use of GeoGebra software is achieved on the indicator of interest in the media and the indicator that has the lowest percentage lies in the indicator of the use of images.
5. Acknowledgements
On this diverse occasion, allow us to express our deepest gratitude to the leadership of IKIP Siliwangi, especially the Chancellor of the IKIP Siliwangi who has given moral and material encouragement to the author to complete this paper.

6. References
[1] Imswatama A 2016 Analisis kesalahan mahasiswa dalam menyelesaikan soal geometri analitik bidang materi garis dan lingkaran Suska J. Math. Educ. 2 1–12
[2] Baharuddin I 2014 Efektivitas penggunaan media video tutorial sebagai pendukung pembelajaran Matematika terhadap minat dan hasil belajar peserta didik SMA negeri 1 Bajo kabupaten Luwu Sulawesi Selatan J. Nalar Pendidik. 2
[3] Trianto I B and Ibnu B 2014 Mendesain model pembelajaran inovatif, progresif, dan kontekstual Jakarta Prenadamedia Gr.
[4] Hosnan M 2014 Pendekatan saintifik dan kontekstual dalam pembelajaran abad 21: Kunci sukses implementasi kurikulum 2013 (Ghalia Indonesia)
[5] Hamzah A and Muhlisrarini M 2014 Perencanaan dan Strategi Pembelajaran Matematika (Depok: Raja Grafindo Persada)
[6] Purwanti R D, Pratiwi D D and Rinaldi A 2016 Pengaruh Pembelajaran Berbatuan Geogebra terhadap Pemahaman Konsep Matematis ditinjau dari Gaya Kognitif Al-Jabar J. Pendidik. Mat. 7 115–22
[7] Rahman R 2010 Pengaruh Pembelajaran Berbantuan Geogebra Terhadap Kemampuan Berpikir Kreatif dan Self-Concept Siswa J. UPI Bandung
[8] Nari N 2018 Penggunaan Software Geogebra Untuk Perkuliahan Geometri PROCEEDING IAIN Batusangkar 1 307–14
[9] Dewi S 2016 Pengembangan Modul Matematika Diskrit berbasis Information and Communication Technology (ICT)
[10] Siswanto R D and Kusumah Y S 2017 Peningkatan Kemampuan Geometri Spasial Siswa SMP Melalui Pembelajaran Inkuiri Terbimbing Berbantuan GeoGebra JPPM (Jurnal Penelit. dan Pembelajaran Mat. 10
[11] Wahyuddin M 2016 Pengaruh Metakognisi, Motivasi Belajar, dan Kreativitas Belajar Terhadap Kemampuan Pemecahan Masalah Siswa Kelas VIII SMP Negeri 2 Sabbangparu Kabupaten Wajo Daya Mat. J. Inov. Pendidik. Mat. 4 72–82
[12] Mahmudi A 2011 Pemanfaatan GeoGebra dalam Pembelajaran Matematika Seminar Nasional LPM UNY (Yogyakarta) pp 1–10
[13] Suraji S, Mainunah M and Saragih S 2018 Analisis Kemampuan Pemahaman Konsep Matematis dan Kemampuan Pemecahan Masalah Matematis Siswa SMP pada Materi Sistem Persamaan Linear Dua Variabel (SPLDV) Suska J. Math. Educ. 4 9–16
[14] Chao J Y, Tzeng P W and Po H Y 2016 The Study of Problem Solving Process of e-Book PBL Course of Atayal Senior High School Students in Taiwan Eurasia J. Math. Sci. Technol. Educ. 13 1001–12
[15] Supriadi N 2015 Pembelajaran Geometri Berbasis GeoGebra sebagai Upaya Meningkatkan Kemampuan Komunikasi Matematis Siswa Madrasah Tsanawiyah (MTs) Al-Jabar J. Pendidik. Mat. 6 99–110
[16] Usman M R 2018 Meningkatkan Kemampuan Berpikir Kreatif Matematis Siswa SMA melalui Pembelajaran Inkuiri Berbantuan Software Geogebra pada Pokok Bahasan Program Linear MAJAMATH J. Mat. dan Pendidik. Mat. 1 117–26
[17] Sudihartining E and Wahyudin W 2019 Pembelajaran Berbasis Digital: Studi Penggunaan Geogebra Berbantuan E-Learning Untuk Meningkatkan Hasil Belajar Matematika J. Tatsqif 17 87–103
[18] Oktaria M, Alam A K and Sulistiawati S 2016 Penggunaan Media Software GeoGebra untuk Meningkatkan Kemampuan Representasi Matematis Siswa SMP Kelas VIII Kreano, J. Mat. Kreat. 7 99–107
[19] Siswanto R 2014 Peningkatan Kemampuan Penalaran Dan Koneksi Matematis Melalui
Penerapan Model Pembelajaran Kooperatif Tipe Stad Berbantuan Software Geogebra (Studi Eksperimen Di SMAN 1 Cikulur Kabupaten Lebak Propinsi Banten) *J. Pendidik. dan Kegur. I* 209662

[20] Rohaeti E E and Bernard M 2018 The Students’ Mathematical Understanding Ability Through Scientific-Assisted Approach of Geogebra Software *Infin. J.* 7 165–72