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The Use of GeoGebra in Teaching Analytical Geometry

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Abstract

The problem of interest in online learning becomes a fundamental problem in learning Analytical Geometry. Students' interest in learning Analytical Geometry was a problem that should be solved. Student interest in learning can influence student achievement. This paper focuses on students taking Analytical Geometry at a private university in Indonesia. Analytical Geometry is one of the branches of mathematics that is abstract and requires students' visual skills. Hence, lecturers are key in inculcating students' interest in learning. One alternative that can be used to inculcate students' interest in learning is to use GeoGebra Software. This research is a descriptive-quantitative study. The sample used was students of the class who took Analytical Geometry. 41 students made up the total sample. Non-test instruments are used, with questionnaires distributed via the Microsoft Office Form. The formulation of the research problem is to find out how students' interest in learning is while studying Analytical Geometry, especially using GeoGebra. This research aims to see whether students are more interested in learning when using GeoGebra. As a result, this can serve as a reference for lecturers to practice using GeoGebra in future teaching. The results showed that students' interest in learning was mostly in good categories. This implies that using GeoGebra can address the problem of students' interest in learning Analytical Geometry.

Keywords: Analytical Geometry, GeoGebra, Online Learning, Student Learning Interest, Teaching Geometry.

Introduction

Interest can be defined as an effort to encourage someone to do something (1, 2). Students' interest in learning is an important thing to pay attention to for now (3). Students' interest in learning can also affect their learning outcomes (4-5). Low interest in learning can reduce the enthusiasm for participating in a lecture. Many factors can influence students' low interest in learning. This is particularly pertinent during the COVID-19 pandemic. Online education in Indonesia presents a complex interplay of challenges and opportunities, characterized by inadequate internet infrastructure in rural regions, limited digital literacy among educators and students, and an overall scarcity of resources to support effective online learning (6). The COVID-19 pandemic has further accelerated the adoption of online education, highlighting its potential for flexibility and inclusivity (7). However, distance learning still faces substantial barriers, including those evident in specific subjects such as Analytical Geometry (8). Research shows that blended learning models, which combine online and face-to-face instruction, are particularly effective, enhancing student performance and problem-solving skills more than full-online learning (9-10). The progression of online learning in Indonesia, especially in mathematics education, shows a shift from traditional classrooms to digital platforms, driven by technological advancements and educational reforms. Early e-learning initiatives started in the early 2000s, but significant progress was made during the COVID-19 pandemic, which forced a swift move to remote education. The Ministry of Education and Culture launched programs to enhance online learning infrastructure. Tools like GeoGebra became popular for their interactive and visual capabilities in teaching abstract concepts. Despite challenges such as limited internet access in rural areas and varying levels of digital literacy, online learning in Indonesia continues to evolve, creating a more accessible and innovative educational environment.

One contributing factor is that it is still implementing online learning at the beginning of 2022, especially in Indonesia. The ongoing spread

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of the COVID-19 virus has led to the implementation of online learning. The Indonesian government suggested conducting face-to-face learning. Research also shows that students who have an interest in learning will look for opportunities to learn (11), engage in meaningful learning (12), and strive to learn to be more meaningful (13-14). Students who have an interest in learning will be intrinsically motivated. They will be more trying, resistant to facing challenges, and trying consistently to achieve goals (15-16). Students majoring in mathematics education at Teachers College, Universitas Pelita Harapan (UPH) also struggle with the issue of low learning interest. Students are bored with approximately two years of learning conducted virtually (17-19). This discouraged positive relationships with lecturers and their friends (20). Online learning presents numerous challenges, which have led to a decrease in student interest in learning (21). Offering learning media is one way to address the issue of learning interest. (22). Learning media can provide a new atmosphere for students to become more enthusiastic about learning (23). This is particularly useful for mathematics, especially in studying Analytical Geometry as one of the branches of mathematics (24-25).

In Analytical Geometry, students will be faced with the visualization of abstract shapes. Materials such as ellipses and hyperboles are still difficult for students to understand (26). Hence, an appropriate learning media is needed to facilitate the visualization of students in learning Geometry. Through learning media, it is hoped that students can also be more interested in learning and that learning is not monotonous (27). Learning media can be used to attract students' learning interests, especially because learning is still carried out online due to the COVID-19 pandemic (28-29).

One of the learning media that can be used is GeoGebra Software (28). GeoGebra software is closely related to the use of computers where its use can help students, especially in learning Geometry (30). GeoGebra is a software that is suitable for learning geometry. GeoGebra is a mathematical software package that offers a combination of 2D and 3D dynamic geometry software, CAS, and spreadsheet features (31). GeoGebra serves as a free, dynamic, and practical tool for mathematics education worldwide (32). This software can be downloaded for free or used online through the official website at http://www.geogebra.org/ (33-34).

GeoGebra is useful for providing opportunities for students to visualize Geometrical concepts as well as accommodating students who have below-average abilities (35). GeoGebra presents several important features suitable for a variety of mathematical topics, including geometry, algebra, analysis, and statistics (36). The results showed that GeoGebra is very suitable for use in mathematics learning. In addition, GeoGebra also can make students interested in learning (37). Literature has shown that students have a positive response and have an interest in learning when using GeoGebra (38).

This analysis seeks to justify its focus on GeoGebra and Analytical Geometry by identifying gaps in the existing literature that it intends to fill, specifically the need for effective digital tools and methods to improve understanding and performance in these areas, which are currently underexplored.

Therefore, in this study, research was carried out on the use of GeoGebra in overcoming the low interest in student learning which was carried out in the Analytical Geometry course. The purpose of this study is to examine how GeoGebra attracts students' interest in learning Analytical Geometry.

Methodology

This study employed a descriptive quantitative research method. This method is used to describe something learned and draw conclusions about phenomena that can be observed with numbers. Descriptive quantitative research only describes the content of variables without testing specific hypotheses (39). This study distributed a questionnaire using Microsoft Office Forms as its instrument. Data collection for this project used questionnaires with open-ended questions to gather qualitative insights into students' views on learning Analytical Geometry with GeoGebra. These questions aimed to elicit detailed responses about students' interest, perceived benefits, challenges, and overall experiences using the tool. This method provided rich, descriptive data, revealing students' nuanced perspectives on integrating digital tools in their learning. The qualitative data helped identify specific factors influencing students' engagement and motivation and highlighted common themes and patterns in their responses. These insights could inform improvements in instructional strategies and the

effective implementation of GeoGebra in lesson plans.

This research was conducted in Indonesia, at a private university with 41 students in an Analytical Geometry class in 2019. The study included students from one of the private campuses, selected to represent the diverse ethnic backgrounds of the broader student population. Participants were chosen based on their enrollment in mathematics education courses, interest in using digital tools for teaching, and willingness to engage in the study. The group included individuals from various ethnic groups such as Javanese, Sundanese, Bataknese, Balinese, and Chinese Indonesian, ensuring a broad perspective on the use of GeoGebra in teaching analytical geometry. This diversity allowed the study to explore variations in the adoption and effectiveness of digital learning tools across different cultural contexts. The research sample consisted of students enrolled in analytical geometry courses. The indicators used were compiled based on indicators of students' interest in learning. This study uses four indicators namely: student attention to learning, feelings of pleasure or displeasure, student interest in learning, and student involvement in learning (40-41). From these four indicators, a statement containing students' interest in learning related to the use of GeoGebra in the Analytical Geometry class was compiled. From each statement, it will be seen at what level the category of student learning interest is included. The questionnaire used a Likert scale with the answer choices strongly agree (SA), Agree (A), Doubtful (D), Disagree (DA), and Strongly Disagree (SD) (42). The criteria used to see the existence of student interest in learning, can be seen in Table

Table 1: Student Learning Interest Questionnaire Categories

Range of Learning Interest Scores	Student Interest Categories
0≤ x≤10	Not Interested
11≤ x≤20	Less Interested
21≤ x≤30	Quite Interested
31≤ x≤40	Interested
41≤ x≤50	Very Interested

x – students score

The data analysis technique used in this study is the percentage formula for student answer results, which is then described using the criteria for interpreting student answer results. The formula calculates the percentage of students in each category based on their interest in learning.

$$PM = \frac{K}{Js} \times 100\% \qquad [1]$$

where:

PM = Percentage of many students from each category of interest in studying

K =Many students from each interest category

Js =Many students filled out the questionnaire

Next, data were presented based on the number of student answers in filling out the student learning interest questionnaire after using GeoGebra. The data collected from the questionnaires were analyzed based on specific indicators of student learning interest in Analytical Geometry. Each indicator's average was calculated to categorize the levels of learning interest. The questionnaires also provided data on students' responses to learning Analytical Geometry. The discussion presented various student responses, including their interest levels, perceived benefits, challenges faced, and overall experiences using GeoGebra. This data analysis offered in-depth insights into factors that either support or hinder students' interest in learning Analytical Geometry with digital tools, identifying common themes and patterns in their responses. These insights can inform improvements in teaching strategies and the effective implementation of GeoGebra in lesson plans.

Results and Discussion

The number of face-to-face meetings held was 16 meetings. Learning was carried out virtually due to the COVID-19 pandemic, even though some students are exposed to COVID-19. In addition, UPH Teachers College students are students who live in dormitories on campus. Because of the impact of COVID-19, most students studied from their respective homes. The uniqueness of UPH Teachers College students was that they come from various regions from remote parts of Indonesia, various islands, and different backgrounds. The localities were generally far,

and these posted more obstacles to online learning experienced by students. Based on the results of the questionnaire that had been distributed to students, students admitted that they experienced internet network problems, disturbed by their learning concentration due to a less conducive family environment, limitations in building relationships with lecturers and classmates, and boredom due to online learning.

From the above problems, it turned out that these affected students' interest in learning. Students could also experience learning loss due to online learning. So, to overcome this, a solution is needed by providing GeoGebra software in online learning. Previously, students were given provisions about the use of GeoGebra, so that when they perform an assignment with GeoGebra, students can adjust well. The material taught in learning Analytical Geometry included cartesian coordinate systems, line equations, circles, ellipses, parabolas, hyperboles, ellipsoids, paraboloids, and hyperboloids. At each meeting, students were given materials and assignments on a specific topic. Students were then given time to do the questions in groups. Once they were done, they continued to demonstrate their visualization through GeoGebra. At a predetermined time, students then conveyed the results of their work through synchronous sessions. The students could consult the lecturers whenever they had problems. Of the 10 statements above, they can be simplified based on 4 indicators of student interest in learning. Out of the 10 statements, there is 1 statement that contains a negative statement. Table 2 below presents the percentage of total students who answered statements related to the use of GeoGebra. SA means Strongly Agree; A means Agree; D means Doubtful; DA means Disagree; and SD means Strongly Disagree.

Table 2: Percentage of the Number of Students who Answer Statements

No.	Indicator	Percentage of Number of Students				
		SA	A	D	DA	SD
1	Feeling of ease	40,65	39,02	16,26	1,63	2,44
2	Students' interest in learning	20,73	34,15	20,73	13,41	10,98
3	Students are engaged in learning	31,71	33,33	30,08	3,25	1,63
4	Students ' attention to learning	43,90	34,15	18,29	2,44	1,22
	Average	34,25	35,16	21,34	5,18	4,07

From the 4 indicators of interest in learning, students are more dominant in answering very much in agreeing and agreeing. This means that students have a positive response to using GeoGebra. Of the 41 students, there are 34.25% of students who can be said to have a very high interest in learning, 35.16% of students have a high interest, 21.34% have a moderate interest in learning, 5.18% have less interest in learning, and 4.07% can be said to be not interested in using GeoGebra. The percentage is obtained based on the average of each indicator of interest in learning. It can be seen that more than 50% of students have a high interest in learning when using GeoGebra. More precisely, 69.41% of students have an interest in learning when using GeoGebra. Students' interest in learning while studying Analytical Geometry can be seen in Table 3.

In Table 3, the data of students who are quite interested is 4.88% of the 41 students. 53.66% or 22 students are in the interesting category and 41.46% or 17 students are in the very interesting category. It can be concluded that the students' responses to using GeoGebra are positive. Students' responses to using GeoGebra can be seen in the statements written by students.

In Table 4 are students' responses after using GeoGebra. In general, it can be divided into 7 aspects namely.

Table 3: Student Learning Interest

Range of Learning Interest Scores	Category	Number of Students	Percentage
$0 \leq x \leq 10$	Not Interested		
$11 \leq x \leq 20$	Less Interested		
$21 \leq x \leq 30$	Quite Interested	2	4,88
$31 \leq x \leq 40$	Interested	22	53,66
$41 \leq x \leq 50$	Very Interested	17	41,46
Total		41	100

Table 4: Students' Responses When Using GeoGebra

No.	Aspects	Student Statement
1	Interesting because it can make 3D animation	"3D display is very helpful in analyzing the problem" "The use of 3D can see the shape of a ball or other wakes up intact" " GeoGebra helps in finding the value of a function only by adding its function to the GeoGebra and comes also with images that can be selected in 2D or 3D form" "Through 3D graphics, the visualization is clearer and looks real or not abstract, then it can be rotated seen from all sides of the image formed"
2	Interest because of GeoGebra visualization/view	"The visual appearance is simple; it can be adjusted as you wish" "The graphic image is clear which facilities comprehension" "The visualization is interesting and very detailed" "Helps to visualize the image and from the image can estimate the possibilities of the concepts that are in it" "The visualization makes it easier for us to understand the picture of the existing formula"
3	Like because of the features that GeoGebra provides	"In 3D and 2D Geometry, the available features are complete and have a description (tutorial) of the functions to be included" "The visualization and fairly complete features" "Its many tools and many features that can be used" "Perhaps it is the style bar algebra view that allows us to see a list of objects that have been created in terms of algebraic structures. In addition, we can also hide temporary objects or customize objects"
4	User friendly and practical to use	"User friendly and easy to use. Its attractive and clear appearance helps me to understand the intent of the questions, especially since my learning style tends to be visual, making me happy to dig deeper into the features in GeoGebra" "What I like most is that this application can represent the material, so that it can better understand concepts such as focal points, latus of the rectum, etc." "What I like the most is that GeoGebra can solve problems without working on them with formulas "
5	Like because of the calculations that GeoGebra can do	"GeoGebra calculations are quite helpful in the accuracy of the means used such as radius calculations" "Can visualize the equations of several curves" "Make it easier to learn and do questions" "I really like the visuals provided by GeoGebra, because it really trains my thinking power, especially in understanding the problem to the process of solving the problem"
6	Dislike	"Because we are looking for the correct answer from what has been provided" "So far I have nothing in particular to like because I am not very reliable in operating GeoGebra"

From the students' response in Table 4, it can be seen students like to use GeoGebra, because of the existence of 3D which makes it easier for students to form spaces such as balls, paraboloids, ellipsoids, and other wakes. Students are also happy because of the GeoGebra visualization that can be adjusted as desired. Students also found GeoGebra simple and easy to use. With the visualization provided by GeoGebra, students can easily understand what is referred to as the latus rectum, focal point, eccentricity, and others. Besides that, the features in GeoGebra are very helpful for users to provide a

clear picture. In addition, students can easily go to the website www.geogebra.org and enjoy various features that help users. The features provided include calculators, tutorials using GeoGebra, creating graphs, and creating statistical equations and curves.

Through GeoGebra, students can generate graphs quickly and accurately compared to using pencils and rulers. In addition, students also gain a clearer visual experience in understanding mathematical concepts equipped with motion animations. GeoGebra can also be used as an evaluation to ascertain whether the paintings and graphics made are correct (43). Students only need to enter the points on the X, Y, or Z axis and enter the equation so that a construct can be formed as desired. In addition to the ball, many constructs can be formed, namely parabola, hyperbole, ellipse, and others. Figure 1 is an example visual that can be created with GeoGebra.

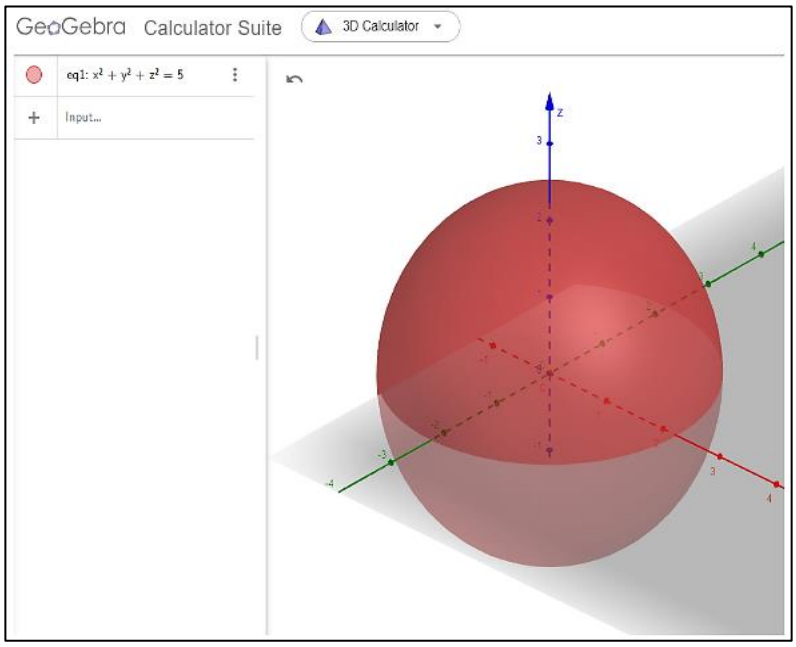

Figure 1: GeoGebra Application Example

Students can also feel the practicality of using GeoGebra because complicated calculations can be helped by the existence of the software. This is because GeoGebra can also function as a calculator. So, it can be said that the use of GeoGebra can attract students' interest in learning. Students' interest in learning will later trigger student enthusiasm for learning, motivating students in a better direction (44).

GeoGebra significantly enhances the comprehension and instruction of analytical geometry in an online environment through its interactive and dynamic features that facilitate visual learning and engagement. By allowing students to manipulate geometric figures and observe real-time changes, GeoGebra helps bridge the gap between abstract mathematical concepts and their visual representations, making it easier for students to grasp complex ideas. Its user-friendly interface and comprehensive toolset enable educators to create dynamic lessons that can be easily shared and accessed online, providing a more interactive and personalized learning experience. Furthermore, GeoGebra supports collaborative learning by enabling students to work on shared projects and explore geometric concepts together, even in a virtual setting. The platform's ability to integrate seamlessly with various learning management systems enhances its utility in the online education landscape, ensuring that students receive consistent and comprehensive instruction in analytical geometry despite the challenges of remote learning. This makes GeoGebra an invaluable resource for both teachers and students, addressing specific gaps in the current online education framework for analytical geometry.

However, despite the many benefits of GeoGebra for students, lecturers certainly need to be vigilant

in using this application. Concerns arise if later this application makes students dependent. The purpose of learning mathematics itself is not just to make use of the application of mathematics instantly. Students also need to have good mathematical abilities. Therefore, it was found that there were students who did not like to use GeoGebra. The reason given was because of computer PC problems. Some students felt that they were not reliable using GeoGebra as they were confused when using GeoGebra. Another reason is that through GeoGebra, students will have a strong desire to do Geometry. Students are faced with questions about the higher-order thinking model which demands students' mathematical ability. Emphasizing GeoGebra and analytical geometry in online education is significant because they address current deficiencies and obstacles such as the lack of interactive and engaging tools for teaching abstract mathematical concepts. GeoGebra's dynamic and visual learning capabilities help students better understand and retain complex ideas in analytical geometry, bridging the gap between theoretical knowledge and practical application. This focus not only enhances student engagement and interest but also provides educators with effective resources to overcome challenges related to limited digital literacy and inadequate instructional materials. By integrating GeoGebra into the curriculum, online education can become more interactive, inclusive, and effective, ultimately improving learning outcomes and addressing existing barriers in the educational landscape.

Conclusion

The use of GeoGebra in attracting student learning interest can be said to be successful because students' interest in learning was mostly in good categories. However, lecturers need to be more vigilant in using GeoGebra. This is to ensure that the use of this application does not make students dependent.

Abbreviations

Nil.

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Author Contributions

Based on personal experience, the first author proposes the idea of GeoGebra to improve student learning interest. The first author also becomes a team leader in the research and also teaching an Analytical Geometry course. The second author contributed to collecting data that did with online learning. The third author supports writing articles and proofreading. All authors have also approved of the final version of this article.

Conflict of Interest

The authors declare no conflict of interest.

Ethics Approval

Not applicable.

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