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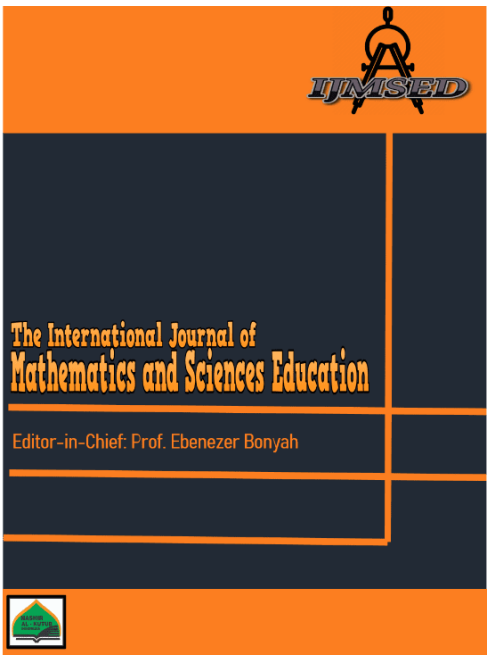

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Use of GeoGebra integrated screencast media: Can it help students improve mathematical understanding in online tutorial activities?

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Abstract
The Calculus I course is a course that has a high level of difficulty, tutors need to find the right way to convey mathematical concepts in this course. One method used to help students understand the Calculus 1 course is by using Screencast Media assisted by the Geogebra application. This research aims to determine the effectiveness of using Screencast media assisted by Geogebra in improving mathematical understanding skills in the Calculus I course. This research design uses a group Pretest-Posttest Design. The participants involved in this research were 35 online tutorial students who took the Calculus I course. Furthermore, data collection in this research used a concept understanding test. Data obtained from the test results were analyzed using the one-sample t-test. The research results show that the use of screencast media assisted by Geogebra effectively increases students' mathematical understanding in the Calculus I course. Students can easily understand mathematical concepts conveyed through video screencasts assisted by Geogebra. Thus, the implementation of this media is expected to improve the quality of teaching and mathematical understanding of students in higher education.

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1. Introduction

The Calculus I course is a mandatory course that students must take in both the Mathematics Education Study Program and other study programs at the Faculty of Teacher Training and Education (FKIP). However, this course has a high level of difficulty, as evidenced by the exam results of the previous three semesters which show that more than 50% of students obtained poor grades. Students' lack of understanding of this course is a major concern. Understanding concepts is an important ability that must be possessed to study any subject, including Calculus I. Mathematical understanding includes the ability to understand mathematical concepts, apply mathematical operations, and a link between concepts in mathematics (Pujiati et al., 2018; Septian et al. al., 2022). With this mathematical understanding, students are expected to be able to use the mathematical knowledge they have learned to solve mathematical problems and problems in everyday life (Runisah et al., 2021).

Based on initial studies, several difficulties faced by students in learning calculus include: (1) not being able to identify the problem given properly, (2) not understanding the initial requirements or assumptions that must be met in solving illustrative problems, (3) not understanding the use of formulas. , (4) errors in choosing a formula that suits the situation and conditions of the problem, and (5) errors in problem-solving procedures (Junaidi & Taufiq, 2021; Septian et al., 2022). Understanding ability is the most basic cognitive ability but is the foundation for understanding higher abilities such as application, analysis, synthesis, and evaluation (Budianti & Mustika, 2017). Therefore, it is important to ensure that students have

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good mathematical understanding skills so they can master more complex mathematical concepts (Fatihah et al.,2023; Prihandika & Perbowo, 2024; Sudirman et al., 2023), including in the Calculus I course. One effort that can be made is to utilize learning media that makes it easier for students to understand mathematical concepts.

The use of screencast learning media assisted by the GeoGebra application can be one solution to overcome students' difficulties in understanding concepts in the Calculus I course. Screencasts are visual recordings of an application or digital activity accompanied by audio narration to explain the processes that occur on the screen (Wakit, 2023). Screencast allows users to display what is happening on their computer screen with the messenger's voice narration. The use of screencasts in mathematics learning can make it easier for students to understand the concepts being explained because they can see the work process directly through a screen display accompanied by audio narration (Pujiati et al., 2018; Ma'ruf et al., 2023). To explain complex mathematical concepts in the Calculus I course, screencasts can be combined with the use of the GeoGebra application. GeoGebra is a dynamic mathematics application that allows users to visualize mathematical concepts (Pujiati et al., 2018; Junaidi & Taufiq, 2021). The combination of screencast and GeoGebra is considered to be able to help students understand the mathematical concepts taught in the Calculus I course.

In online tutorial activities, students are given an initiation containing Calculus I material. So far, the initiation given is only in the form of text and static images, so students are less enthusiastic about studying the material presented. This research uses screencast media assisted by GeoGebra which can make it easier for students to understand complex mathematical concepts. The ability to understand mathematical concepts is an essential ability that students must have. Understanding mathematical concepts can be interpreted as the ability to understand concepts, operations, and relationships in mathematics subjects (Pujiati et al., 2018). This is important because a strong understanding of mathematical concepts can help students develop higher mathematical abilities, improve problem-solving, and apply mathematics in everyday life (Unaenah et al., 2023).

Even though understanding mathematical concepts is considered important, in mathematics learning students often only memorize mathematical formulas without understanding the underlying concepts (Septian et al., 2022). This suboptimal understanding of mathematical concepts can be caused by several factors, including the use of less varied learning media and a lack of interactivity in mathematics learning (Pujiati et al., 2018). Therefore, an alternative learning media is needed that can improve students' understanding of mathematical concepts in the Calculus I course. One learning media that can be used is screencasts combined with the GeoGebra application. Screencast is a recording of digital activity on a computer screen which can be accompanied by sound recording (Klau & Samo, 2021). Screencasts can be an effective medium for conveying mathematical concepts because they can display the steps for solving mathematical problems visually and in audio (Klau & Samo, 2021). Meanwhile, GeoGebra is an interactive mathematics application that can help students visualize mathematical concepts (Sunismi et al., 2023). By using GeoGebra, students can actively explore mathematical concepts so they can improve their understanding (Sunismi et al., 2023). Therefore, this research aims to determine the effectiveness of using screencast media assisted by GeoGebra in improving students' mathematical understanding in the Calculus I course in online tutorial activities.

2. Method

This research uses one-group pretest-posttest quasi-experimental research. Research design is used to evaluate the effect of a treatment or intervention on a single group. In this study, measurements were carried out twice, namely before treatment (pretest) and after

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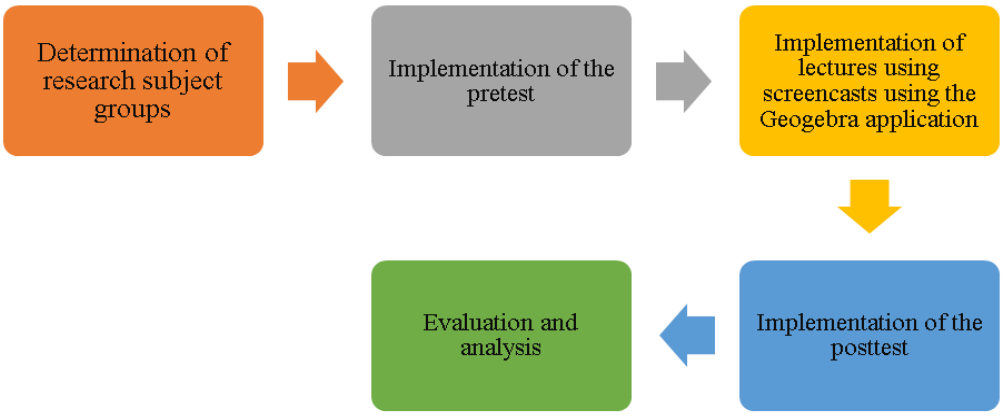
treatment (posttest). The difference between the pretest and posttest results is used to assess the effectiveness of the treatment. The One Group Pretest-Posttest steps can be seen in Figure 1.

Figure 1

Research Implementation



In research using GeoGebra-assisted Screencast design, several stages must be gone through. First, determining the research subject group was carried out by selecting a group of students who would become participants, for example, 35 students who took the Calculus I course online. Second, the pretest is carried out to measure students' initial understanding of the concepts that will be taught. This pretest can be a written test or an online quiz. Third, lectures were carried out using screencasts with the GeoGebra application. At this stage, students watch a screencast that explains calculus concepts visually with clear narration, so they can see and hear the steps to solve the problem. Fourth, after students have studied the material through screencasts, a posttest is carried out to measure their understanding after the treatment. This posttest can be a written test or online quiz which is the same or similar to the pretest. Finally, evaluation and analysis is carried out by comparing the pretest and posttest results for each student. The results of this evaluation will show the effectiveness of using GeoGebra-assisted screencasts in improving students' mathematical understanding.

Participants in this research were 35 students who took Calculus I courses in online tutorial activities. Of the 35 students who attended the lecture, 25 students were female and 10 students were female. The age distribution is from 18-30 years. Before starting the research, the researcher asked for permission first and conveyed the researcher's intentions. Therefore, 35 students voluntarily agreed to take part in the Calculus 1 lecture process.

The data collection procedure in this research is as follows: 1) Giving an initial test (pre-test) to measure students' understanding of mathematical concepts before being given treatment, 2) Giving treatment in the form of learning using screencast media assisted by GeoGebra, 3) Giving a final test to measure understanding students' mathematical concepts after being given treatment. The data collected in this research were students' mathematical concept understanding scores, which were obtained from the initial and final tests. Concept understanding tests were given before (pre-test) and after (post-test) learning using screencast media assisted by GeoGebra. The data analysis in this study used a one-sample t-test. The data analysis aims to determine the picture of students' understanding of mathematical concepts before and after using screencast media assisted by GeoGebra and then analyzed descriptively to determine the increase in students' mathematical understanding after using screencast media assisted by GeoGebra.

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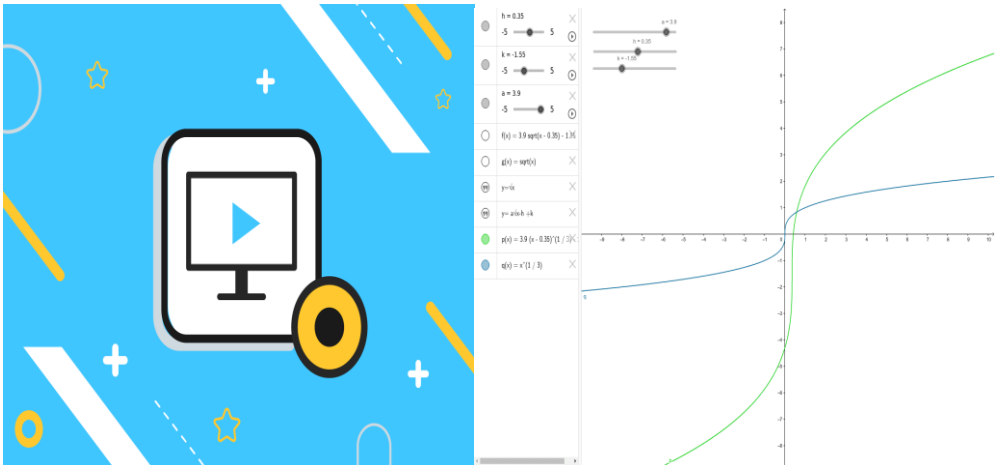
3. Results and Discussion ←12pt, Times New Roman, Bold

Results

a. Implementation of Lectures

GeoGebra integrated screencast media is a learning method that combines screen recordings (screencasts) with GeoGebra software to help students understand calculus concepts visually and interactively. This screencast will be used in online tutorial activities to provide a step-by-step explanation of the material being taught. The appearance is as in Figure 2.

Figure 2
GeoGebra integrated screencast



The aim of using GeoGebra integrated screencast media in learning Calculus 1 is to help students understand basic calculus concepts, such as limits, derivatives and integrals. With a strong understanding of these concepts, students are expected to be able to follow developments in the material more easily and effectively. Apart from that, another goal is for students to be able to use GeoGebra to visualize and manipulate mathematical functions so that they can see directly how changes in these functions affect graphs and calculation results. Lastly, students are expected to be able to develop problem-solving skills in calculus with the help of GeoGebra, so that they are better prepared to face academic and practical challenges in the field of mathematics.

To support this learning, several tools and materials must be prepared. First, students must have a computer or laptop with a stable internet connection so they can access online tutorials and use the necessary software. The main software used is GeoGebra, which will help in the visualization and manipulation of mathematical functions. Additionally, instructors need to use screen recording software such as OBS Studio or Screencast-O-Matic to create screencasts explaining calculus material. Finally, the Open University e-learning platform will be used to upload materials, and screencasts and interact with students during online tutorials.

Learning with GeoGebra integrated screencast media is carried out through several steps. First, the instructor prepares calculus material which covers topics such as limits and continuity, derivatives and their applications, and integrals and their applications. Next, the instructor creates a screencast consisting of recorded concept explanations, step-by-step demonstrations, and interactions and exploration using GeoGebra. The screencast that has been created is then uploaded to the Open University e-learning platform along with other supporting materials such as lecture notes, presentation slides, and practice questions. Implementation of online tutorials is carried out through live tutorial sessions using video conference platforms such as Zoom or Microsoft Teams, discussion forums for questions and discussion of material, as well as assignments and evaluations that utilize GeoGebra in solving calculus problems.

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b. Data Analysis Results

In the initial tutorial activity, before entering the material section (initiation), students were given a pretest, the results of which are in Table 1.

Table 1
Pre-test Data

		Frequencies	Percent	Valid Percent	Cumulative Percent
Valid	1	5	14.3	14.3	14.3
	2	18	51.4	51.4	65.7
	3	12	34.3	34.3	100.0
	Total	35	100.0	100.0	

The first interpretation of the pretest results shows that all students scored below the passing standard, indicating significant difficulties in understanding Calculus 1 material. In this context, low scores on the multiple-choice test with 4 answer options indicate that students may have difficulty in basic concepts. such as limits, derivatives, and integrals. This can be caused by various factors, including ineffective teaching methods or a lack of visual aids that can help students visualize abstract concepts in calculus.

After implementing learning using screencast media assisted by GeoGebra, it is hoped that students' understanding of the material will increase. GeoGebra, as a visual aid, allows students to see directly how changes in mathematical functions affect graphs and calculation results. With screencast support, students can follow the instructor's explanations more interactively and flexibly, allowing them to learn according to their own pace and learning style. The post-test results after learning with this media will be an important indicator to assess the effectiveness of this new teaching method, it is hoped that it will show a significant increase in scores above the passing standard.

Furthermore, the post-test result data is as in Table 2.

Table 2
Posttest results

		Frequencies	Percent	Valid Percent	Cumulative Percent
Valid	6	3	8.6	8.6	8.6
	7	17	48.6	48.6	57.1
	8	13	37.1	37.1	94.3
	9	2	5.7	5.7	100.0
	Total	35	100.0	100.0	

Interpretation of this data shows the distribution of posttest scores from 35 students after participating in learning using screencast media assisted by GeoGebra. From this data, 3 students (8.6%) got a score of 6, which is the lowest score in this distribution. A grade of 7 was obtained by 17 students, or 48.6% of the total student body, indicating that almost half of the class achieved this grade. A total of 13 students (37.1%) got a score of 8, which also shows a significant improvement in understanding the material. Only 2 students (5.7%) received the highest score of 9, indicating that although there has been significant improvement in understanding, there is still room for improvement so that more students achieve the highest score.

From a cumulative perspective, 57.1% of students obtained a score of 7 or more, and 94.3% of students obtained a score of 8 or more, indicating that the majority of students achieved or exceeded the passing standard after participating in learning using screencast media assisted by GeoGebra. The fact that 100% of students scored between 6 and 9 shows a significant improvement compared to the pretest, where all students were below the passing

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standard. Thus, this data supports the effectiveness of using screencasts and GeoGebra in improving student understanding and performance in Calculus 1.

Furthermore, the results of the analysis of the *Paired Sample t-test data* obtained results as in Table 3.

Table 3
Paired Sample Test Results t-test

Paired Samples Test										
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre_test - Post_test	28.726	4.523	3.107	-46,836	-54.024	3.654	34	.000

Interpretation of Paired Samples Test data shows a significant difference between students' pretest and posttest scores after participating in learning using screencast media assisted by GeoGebra. The average value (Mean) of the difference between the pretest and post-test is 28.726 with a standard deviation of 4.523 and a standard error of the mean of 3.107. The 95% confidence interval for this difference ranges from -46.836 to -54.024, indicating that this difference is statistically significant and consistent in the sample population. The t value of 3.654 with 34 degrees of freedom (df) indicates that the increase in the posttest value compared to the pretest is very significant, with a p-value (Sig. 2-tailed) of .000 which is far below the significance level of 0.05.

These results confirm the hypothesis that the use of screencast media assisted by GeoGebra has a significant positive impact on student understanding in the Calculus 1 course. An increase in the average score of 28,726 indicates a substantial increase in understanding of the material after this learning intervention. High statistical significance ($p < .000$) confirms that the observed differences are not the result of chance, but rather a real effect of the learning method applied. Thus, these results support the effectiveness of using screencasts and GeoGebra as teaching aids to improve student academic performance in calculus material.

Discussion

The findings of this study are in line with previous research that has demonstrated the efficacy of technology-enhanced learning tools in improving student understanding and performance in mathematics. Budianti & Mustika (2017) found that the use of reciprocal teaching models significantly enhanced students' mathematical concept comprehension. Similarly, Klau & Samo (2021) reported that the application of GeoGebra in a scientific approach significantly boosted student motivation and learning outcomes in quadratic function topics. The substantial increase in average scores observed in our study corroborates these results, highlighting the effectiveness of integrating screencasts with GeoGebra to facilitate a better understanding of complex calculus concepts.

Moreover, the high statistical significance ($p < .000$) of the observed improvements aligns with the theoretical framework suggesting that interactive and visual learning tools can profoundly impact students' cognitive processes. GeoGebra's dynamic visualization capabilities help students grasp abstract mathematical concepts more concretely, while screencasts provide a flexible and accessible medium for repeated review and self-paced learning. These results are consistent with Junaidi & Taufiq (2021) findings on the positive impact of inquiry-based learning methods on students' mathematical communication skills. Therefore, this study reinforces the theoretical underpinnings and empirical evidence supporting the integration of technology in mathematics education, confirming its significant positive impact on student learning outcomes.

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Furthermore, our results extend the findings of Pujiati et al (2018), who showed that contextual teaching and learning with the aid of concrete materials improved students' conceptual understanding. In the context of our study, the screencast and GeoGebra combination provides a similar function by offering concrete visual representations of abstract calculus concepts. This approach allows students to manipulate variables and observe the resulting changes in real time, thus deepening their conceptual understanding.

Additionally, our study's findings align with Ridwan & Panjaitan's (2022) research on the effectiveness of web-based learning media in mathematics education. The integration of screencasts offers an asynchronous learning tool that students can access at their convenience, thus accommodating diverse learning paces and styles. This flexibility is particularly beneficial in a distance learning environment, as demonstrated by Ma'ruf et al (2023), who found that contextual teaching and learning modules significantly improved student outcomes in linear inequality topics. Our study similarly suggests that the use of screencast media, coupled with interactive tools like GeoGebra, provides a robust framework for enhancing student engagement and understanding in calculus.

This study also corroborates the work of Sunismi et al (2023), who highlighted the importance of workshops in using GeoGebra for teaching mathematical concepts. Their findings underscore the need for hands-on training and practice to maximize the benefits of GeoGebra. In our context, the use of screencasts not only provides theoretical knowledge but also practical demonstrations that students can repeatedly watch and practice on their own. This method aligns with the idea that repeated exposure and active manipulation of learning materials can significantly enhance student understanding and retention of mathematical concepts. Overall, the integration of screencasts and GeoGebra has proven to be an effective teaching strategy that aligns well with current educational theories and previous research findings in mathematics education.

4. Conclusion

Based on the research results, it can be concluded that the use of screencast media assisted by GeoGebra is effective in improving students' mathematical understanding in the Calculus I course in online tutorial activities. This effectiveness is demonstrated by the significant improvement in students' concept understanding test scores after the learning intervention using screencast media and GeoGebra. The screencast media aids students in understanding mathematical concepts both visually and audibly, while the GeoGebra application enhances their ability to visualize these concepts dynamically. This combination provides a powerful and interactive learning experience that significantly enhances students' comprehension of calculus.

Moreover, the integration of screencast media and GeoGebra offers students the flexibility to learn at their own pace and revisit complex topics as needed, promoting self-directed learning and deeper engagement with the material. The ability to manipulate and explore mathematical functions through GeoGebra fosters an interactive learning environment, making abstract calculus concepts more tangible and easier to understand. This approach not only improves immediate academic performance but also builds a stronger foundation for future mathematical learning. Therefore, the use of screencast media and GeoGebra as teaching tools in online tutorial activities is highly recommended for enhancing student understanding and achievement in calculus.

Limitations

The limitations of this study lie in the context of using screencast media and GeoGebra, which were proven effective in improving students' understanding in the Calculus I course, but only tested in an online tutorial environment. The results may not be generalizable to other learning contexts, such as face-to-face instruction or courses with different formats. Additionally, this study does not address other

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factors that may influence the outcomes, such as individual differences in technical proficiency with GeoGebra or students' learning preferences. The long-term impact of using these tools on advanced mathematical understanding has also not been thoroughly explored.

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Author Contribution
Conceptualization, Writing - Original Draft, Editing, Visualization; Writing - Review & Editing, Formal Analysis, and Methodology; Validation and Supervision.

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Conflict of Interest
The authors declare no conflict of interest.

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