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Research Article

Technology integrated learning optimization in calculus topic in the new normal era

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Abstract

The purpose of this research is to provide alternative mathematics learning facilitated by optimal use of technology to produce good student learning outcomes. Some of the technology-based media or platforms used in this research are WhatsApp Group, Google Meet, Pen Tablet, Screen Recorder, YouTube, and Learning Management System. This research is a descriptive case study that aims to be descriptive and provide a comprehensive picture related to technology-based mathematics learning in calculus course. The subjects in this research were 39 students of Informatics Engineering, University of Mataram, Semester I. The data obtained in this research were analyzed quantitatively using descriptive methods. Data on learning outcomes was obtained from tests that were carried out three times during lectures. The results showed that at the end of the lecture, the final score mean of students reached 80.40, with 100% of students meet the pass criteria. This shows that learning in calculus course by utilizing technology really helps lecturers and students optimize student learning outcomes.

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Introduction

The COVID-19 pandemic has an impact on the changes in human life activity, so that the new normal era occurs all over the world. The new normal era is a change in behavior in a society to keep on doing normal activities by implementing health protocols to prevent the spread of COVID-19. This change is happening in all sectors of life, including the education sector. The pandemic requires all educators and learners to adapt to new learning styles. So this contributes to the influence on learning in the new normal era. Nowadays the skills and needs of educators and learners in using technology are increasing.

Many of the advantages of learning using technology (Widianto, 2021), especially in mathematics learning, include providing students with the opportunity to learn independently, the time and place of learning are flexible, can be done anytime, anywhere, but with intermediaries using electronic media, enhancing the activity and creativity of learners in developing their ideas, and equipping learners with global knowledge. In addition, some of the principles of technology-integrated learning (Hadisi & Muna, 2015) are to enable the active participation of learners through interesting and meaningful learning, enable learners to incorporate new ideas, give the learners the opportunity to work in groups or societies, and allow students to actively and enthusiastically strive to what they want. Additionally, several studies have

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also shown that technology-based media can facilitate effective mathematics learning (Salsabila et al., 2022; Salsabila & Setyaningrum, 2020).

One of the mathematics course that can be maximized with the help of technology is calculus. Calculus is one of the cross-course in the field of mathematics that must be completed by students of S1 Engineering Informatics University of Mataram. The calculus course at University of Mataram consists of several topics, such as Logic and Set; Sequences and Series; Matrix and System of Linear Equations; System of Real Numbers; Functions and Graphs; Limits and Continuity; Derivatives; and Integrals. Calculus is one of the courses to enhance predictive skill and is necessary as it is a way to further enhance deductive reasoning (Mutakin, 2015). Besides, mathematics is also known for its hierarchical matters and for producing efficient language, which engineering students are in great need of.

Several previous studies have been conducted to optimize calculus learning using technology. Maskar & Dewi, (2020) stated that the GeoGebra-assisted online calculus material could be implemented as an alternative to calculus learning. The media used consists of GeoGebra, videos from YouTube, Latex Online usage, and online evaluations such as quizzes or online tests in real-time. Then animation-based teaching materials with contextual approaches and local wisdom are able to attract student interest in learning calculus (Novianti & Shodikin, 2018). Students responded positively to the material with criteria very well seen in terms of material content, graphic-animation and readability. Moreover, the use of ICT (Information and Communication Technologies) based student worksheets can be effectively used in further calculus learning (Wahyuni & Kurniawan, 2019). Based on these findings, it can be seen that technology has a lot of positive impact on learning in the classroom.

One of the differences between this research and previous studies lies in the technology platforms used during the learning process. The platforms used in this study include WhatsApp, YouTube, Google Meet, Pen Tablet, Screen Recorder, and Learning Management System. The advantage of using these platforms is that both lecturers and students are very familiar with them. For example, the WhatsApp application is used daily by lecturers and students, especially in Indonesia, as a communication tool. Additionally, YouTube is a very familiar site for both lecturers and students to access. Similarly, Google Meet has been frequently used for learning purposes during the pandemic. It can be said that lecturers and students can easily use these various technology platforms, which positively impacts the learning process.

Optimizing the use of technology in learning at the teaching level in a particular calculus course can make learning more effective and efficient. This research aims to provide a mathematical learning alternative that facilitates the optimum use of technology to generate a good output of student learning. It can be a reference for educators when applying technology-based learning in the classroom.

Method

Research Model

This research is a descriptive case study that aims to make descriptives and provide comprehensive insights related to technology-based mathematical learning in calculus course. The calculus course carried out in this research is technology-based using several platforms namely WhatsApp Group, Google Meet, Pen Tablet, Screen Recorder, YouTube, and Learning Management System of University of Mataram.

Here are some of the topics taught in the calculus course.

- Logic and Set
- Sequences and Series
- Matrix and System of Linear Equations
- Real Number System
- Functions and Graphics
- Limit and Continuity
- Derivatives
- Integral

Participants

The subject of the research in this study is a student of Engineering Informatics University of Mataram Semester I of 39 students. The students consist of 26 male students and 13 female students. The students who were the subjects of this research were enrolled in a calculus course, which is a mandatory course. Additionally, the students were already accustomed to using the technological tools employed in this research.

Data Collection Tools & Process

The data collection techniques used in this research were documentation and testing. The documentation technique was employed to gather data related to the implementation of the calculus course that optimizes the use of technology. Meanwhile, the testing technique was used to collect data on students' learning outcomes after attending the course. The research instrument used to collect data on learning outcomes was a test on calculus material. The learning outcome test was created in the form of essays. This test was given during exams that were conducted three times throughout the course. The test data obtained in this research were analyzed quantitatively using descriptive methods. The division of topics for each calculus exam is as follows.

Table 1. The distribution of topic on the calculus exam

Exam	Topic
1st Exam	Logic and Set; Sequences and Series; Matrix and System of Linear Equations; Real Number System
2nd Exam	Functions and Graphics; Limit and Continuity
3rd Exam	Derivatives; Integral

Examination 1 consists of 5 questions, examination 2 of 6 questions, and examination 3 of 6 questions. Some examples of questions given at the time of examination in the calculus course are as follows.

Example of the 1st exam question:

Ms. Tika borrowed money of Rp.700,000,- from Ms. Risma. Ms. Risa asked Ms.Tika to pay the monthly debt of Rp.52,000, Rp.50,000, Rp.48,000, Rp.46,000, and so on. Mrs. Tika was asked to start paying the amount in October 2022. Determine in which month and year Mrs. Tika last deferred the debt to pay off.

Example of the 2nd exam question:

- Given $f(x) = \frac{4x}{(x^2-8)}$ and $g(x) = \sqrt{2x}$. Find the domain of $(f \circ g)(x)$.
- $\lim_{x \to 1} \frac{x^2+ux-x-u}{x^2+2x-3} = \cdots$

Example of the 3rd exam question:

- Given $f(x) = ax^2 - 4x + 1$ and $g(x) = 3x^2 + ax + 2$. If $h(x) = f(x) + g(x)$ and $k(x) = f(x)g(x); h'^{(0)} = -3$, find $k'(0)$.
- $\int \frac{-16-6x^4}{x^2} dx = \cdots$

This research was conducted during a calculus course over one semester. The course spanned 4 months with a total of 16 sessions, comprising 13 sessions for learning activities and 3 sessions for exams. Some of the learning sessions were conducted both offline or online, utilizing various platforms such as WhatsApp Group, Google Meet, Pen Tablet, Screen Recorder, YouTube, and the Learning Management System of the University of Mataram. Exams, however, were conducted offline.

Results and Discussion

Some media or technology-based platforms used in this course are WhatsApp Group, Google Meet, Pen Tablet, Screen Recorder, YouTube, and Learning Management System of University of Mataram. Here is an explanation of the various uses of such applications or media in learning.

WhatsApp Group

WhatsApp Group is used to communicate with students related to course information. Besides, the WhatsApp Group is also used during classes, both offline and online. During the student practice, the lecturer instructed the students to share their answers in the form of photos in the WhatsApp Group. This can help to make learning more effective and efficient. Compared to pre-pandemic learning, teachers and students never used the WhatsApp Group as a learning platform. Then when exercising, students usually write their answers on a board. Sometimes it takes not a minute if the answers are written long enough. If you use WhatsApp Group, students can share their answers quickly, so the time spent is more efficient. All students in the classroom can also observe the answers shared in the WhatsApp Group and provide responses in person. Students have no difficulty following these instructions because there is wifi on campus that can be used by students to share answers.

Here's a screenshot showing the student's activity during the exercise on the topic where they shared their answers via the WhatsApp Group.

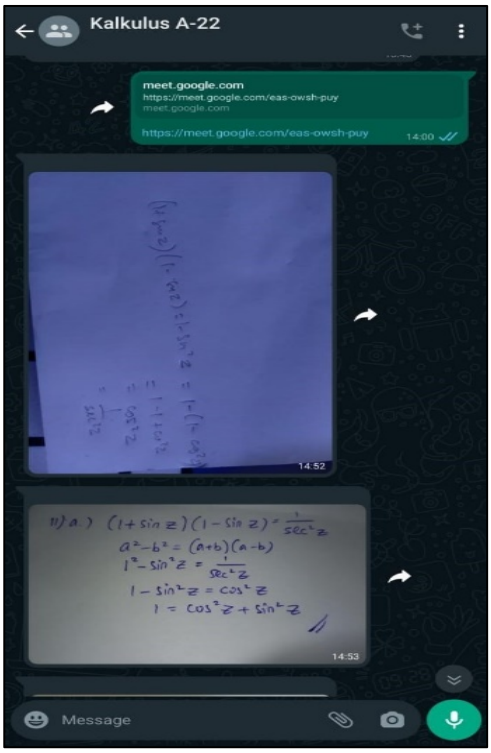

Figure 1. Student answers shared on Whatsapp groups

Google Meet

Google Meet is used when lectures are conducted online. Submission and discussion of material is carried out through Google Meet. Then, during the practice, students share their answers in the form of photos on WhatsApp Group, which can be followed by lecturers and other students. In this way, students can get feedback directly related to their answers even though learning is not carried out face-to-face.

Here's a screenshot of one of the activities at the Google Meet that took place in the calculus course.

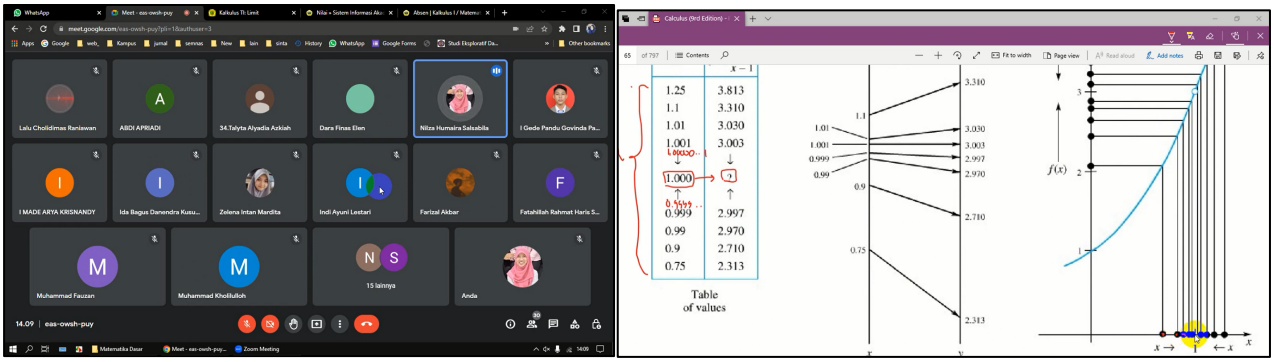

Figure 2. Calculus course through google meet

Pen Tablet, Screen Recorder, and YouTube

One of the technology media used in this course is the pen tablet. Pen Tablet is used by the instructor to facilitate the lecturer when presenting the material through the projector. Then, the screen recorder is used to record the screen of the laptop instructor when presenting the material. The results of the recordings were uploaded to YouTube so that students could re-examine the material delivered through the recordings.

Here's a screenshot of the playlist of the calculus course recordings on the YouTube platform.

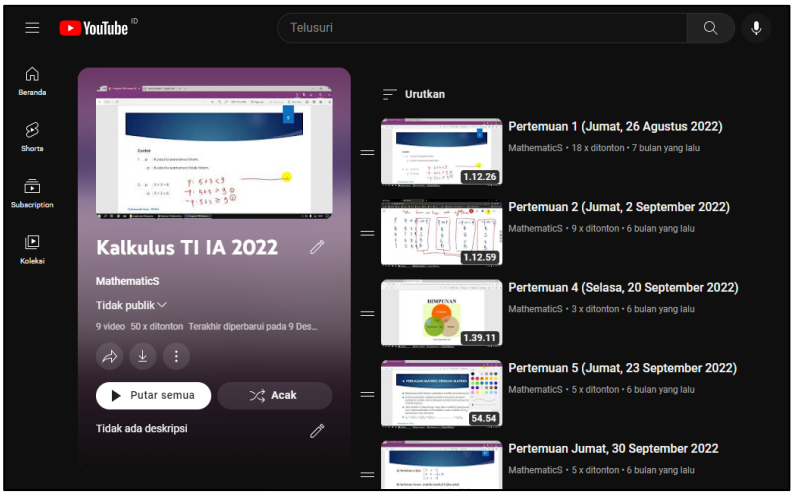

Figure 3. Playlist of calculus course recordings on Youtube

Learning Management System

The Learning Management System (LMS) used during learning activities is the LMS of the University of Mataram. In this course, the LMS forum was used to share course material, Google Meet link, and YouTube playlist link containing course recordings. In addition, LMS is used to distribute tasks to students and place students to gather answers. Students can also discuss their assignment answers asynchronously in LMS. Here are examples of assignments given to students through the LMS.

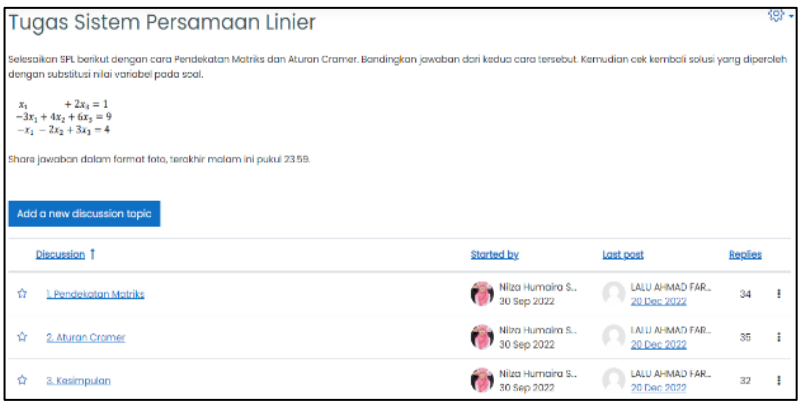

Figure 4. Delivery of duties at University of Mataram LMS

Student Learning Outcomes

The student's study results are obtained from the examinations carried out three times during the course. The examination is done offline so that the lecturer can more easily monitor the examination process. The score for the minimum completeness criteria is 64.

Table 2. Calculus course exam scores

1st Exam	**Mean and Scores**
Mean	73.38
Minimum Score	18
Maximum Score	100
Students with a score > 64	27 (69%)
2nd Exam	
Mean	84.59
Minimum Score	30
Maximum Score	100
Students with a score > 64	37 (95%)
3rd Exam	
Mean	83.23
Minimum Score	55
Maximum Score	100
Students with a score > 64	34 (87%)
Final Score Mean	**80.40**
Passing Students	**100%**

From the table above it can be said that the student's learning outcomes based on their exam scores yield a good output. Most students score above 64, which is the minimum grade of pass. It also appears that students who score more than 64 on the 1st exam get the lowest percentage. However, on the next exam, the student's score increases so the pass rate also increases. At the end of the class, the average final score of students was 80.40 with 100% of students meeting the pass criteria.

In this research, using the WhatsApp Group as a platform for lecturer and students to exchange important information related to course can make the information delivered to students quickly. It is known that the WhatsApp app is one of the applications that are widely used by Indonesian society. In addition, students who share their answers in WhatsApp Groups can help make learning more practical. In-class learning also does not spend much time just writing on a board. All students can also clearly see every answer shared in the WhatsApp Group. Lecturer can respond directly to students' answers when learning, both online and offline.

The practicality experienced by lecturer and students in learning while using the WhatsApp Group can optimize learning in the classroom. More time is available for lecturer and students to discuss the answers that have been shared on the WhatsApp group. This has an impact on student activity and learning outcomes that are increasingly optimum (Apsari et al., 2020).

Then the use of Google Meet in learning helps lecturer and students to keep learning online. The use of synchronous Google Meet can help students to stay active in learning. This condition will affect the student's learning outcomes. Previous research by Mudijono & Azis (2022) explained that college-level math learning using Google Meet can improve student learning outcomes.

The pen tablet used by the lecturer in learning, is very helpful in presenting the material in increasing detail. The lecturer can directly write a description of the material through a laptop screen recording. All the activities in the classroom, both material explanations and discussions are well recorded. Unlike the usual use of a board, the description of material using a board has shortcomings, one of which is that the lecturer is unable to record directly the material presented and discussed. In this calculus course, the use of whiteboard is minimized, while the technology in the classroom is optimized.

The recording of the lesson material shared on YouTube is very helpful to students in reviewing the material they have already obtained in the classroom. These advantages can help students to improve their learning outcomes. The use of YouTube as a learning tool has proven to be effective, demonstrated by the difference in average learning outcomes before and after using YouTube media, it shows that YouTube media use has an impact on student learning outcomes (Julianingsih & Widayanti, 2021).

The Learning Management System provided at University of Mataram also plays an important role in learning in the classroom. Lecturer can give a task to a student through a forum in the LMS. Besides, the collection of tasks is also through forums in the LMS. The student's task answers files can be assembled well, unlike collecting tasks by assembling the answer sheets. Student answer sheets will be more easily scattered. Lecturer will also make it easier to evaluate students by checking the student's task data available in the LMS.

In addition, through LMS students can also discuss asynchronously related to assigned tasks. Advantages of asynchronous learning, students can study anytime and anywhere with the conditions and speed of each student's learning (Darma et al., 2020). This discussion activity will help them build knowledge related to material calculus. Through that, students' learning outcomes will be improved.

Regarding the difficulties of this research, there is one minor obstacle during the learning process using technology. Some students experienced problems in the form of unstable internet connections when participating in learning activities via Google Meet. Unstable internet connection can affect the quality of mathematics learning, because students may lose access to classes or important material taught online (Dhawan, 2020). Apart from that, this causes student engagement in learning will decrease (Adnan & Anwar, 2020) and prevents students from participating actively (Huang et al., 2020).

One way to overcome these challenges is for lecturer to provide recordings of their learning activities during Google Meet sessions, captured using a screen recording application. Then students can access the recording on YouTube. Students who may have missed out on fully participating in the live Google Meet sessions can review the material presented by the lecturer in these recordings. Lecture recordings offer flexibility for students to access the content anytime and from anywhere, allowing them to revisit specific materials as needed (O'Callaghan et al., 2017). Additionally, the learning trail on WhatsApp Groups, where students share their answers during practice exercises, also helps students review missed materials when internet connectivity is inadequate.

Conclusion and Recommendations

Learning mathematics, especially calculus course, by using technology greatly helps lecturers and students to optimize the output of learning. In the new normal era, lecturers and students are becoming more skilled in using technology due to the demands of learning the effects of pandemics. The ability to use this technology needs to continue to beined, even improved to help the learning process of teaching in the classroom. The use of technology can make learning more effective and efficient.

Suggestions for further research, learning by optimizing the use of technology can be applied to other courses, besides calculus, and can be applied to students in different departments. Then the technology used in learning can also be added or replaced with another technology, the newest technology, to maximize the learning process. The campus can also make policies related to learning on campus which must utilize the latest technology in the learning process.

Limitations of Study

The research that has been carried out is only limited to calculus course and research subjects of Engineering Informatics students at the University of Mataram. The technology platforms used are also limited to WhatsApp Group, Google Meet, Pen Tablet, Screen Recorder, YouTube, and Learning Management System of the University of Mataram.

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