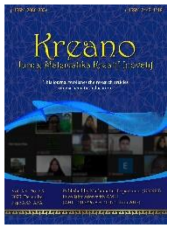
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 15, number 2, 2024, pp. 528-547



Exploring the Use of Mobile Technologies in Indonesian Mathematics Lectures

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Abstract

Despite extensive research on mathematics within universities, yet exploration of alternative solutions for challenges students faced during mathematics lectures was limited. Particularly, integrating mobile technology assistance via didactical design research received little attention. Therefore, researchers tried to describe the role of mobile technology in supporting mathematics lectures at an Indonesian university. Didactic design research was the method used in this research. Participants comprised 53 students aged 18–25 years. The main research tools included the researcher, a math comprehension test, an in-depth interview guide, and a hybrid mathematics module with mobile technology support. Thematic analysis uncovered learning barriers, while lecture data underwent qualitative and retrospective analysis. The findings were low mastery of prerequisites, carelessness, and a limited context for lecture. The hybrid module was able to minimize mathematics student learning obstacles in higher education. This research recommends lecturers facilitate problem-based activities with mobile technology to enhance students competencies in higher education.

Keywords: A hybrid mathematics module; mathematics lectures; mobile technology

Information of Article	
Subject classification	*97U10 Comprehensive works on educational technology in mathematics education*
Submitted	*26 June 2024*
Review Start	*26 June 2024*
Reviewer A Finish	*21 November 2024*
Reviewer B Finish	*21 November 2024*
Accepted	*10 December 2024*
Scheduled online	*14 December 2024*
Similarity Check	*5%*

Abstrak

Cukup banyak penelitian yang mengkaji matematika di universitas, tetapi eksplorasi mengenai solusi alternatif terhadap tantangan yang dihadapi mahasiswa selama kuliah matematika masih terbatas. Khususnya, pengintegrasian teknologi seluler melalui penelitian desain didaktis kurang mendapat perhatian. Oleh karena itu, penelitian ini mencoba untuk mendeskripsikan peran teknologi seluler dalam mendukung kuliah matematika pada sebuah universitas di Indonesia. Didactical design research merupakan metode yang digunakan dalam penelitian ini. Pertisipan terdiri dari 53 mahasiswa berusia 18–25 tahun. Instrumen utama adalah peneliti, tes pemahaman matematika, panduan wawancara mendalam, dan modul matematika hibrida dengan dukungan teknologi seluler. Analisis tematik digunakan untuk mengkaji hambatan belajar, sementara data perkuliahan dianalisis menggunakan kombinasi antara analisis kualitatif dan retrospektif. Temuan penelitian ini adalah penguasaan prasyarat yang rendah, kecerobohan, dan konteks perkuliahan yang terbatas. Modul hibrida mampu meminimalkan hambatan belajar mahasiswa matematika di pendidikan tinggi. Penelitian ini merekomendasikan kepada dosen untuk memfasilitasi kegiatan berbasis masalah dengan teknologi seluler untuk meningkatkan kompetensi mahasiswa di pendidikan tinggi.

INTRODUCTION

Previous theories and studies reveal that mathematics is a useful scientific discipline (Man-Keung, 2022; Yolcu & Popkewitz, 2019). However, mathematics remains a problem in learning, both in schools and universities (Gómez-Chacón, 2017; Lin et al., 2017). There is quite a lot of research examining mathematics in tertiary institutions (Silber & Cai, 2021; Zayyadi et al., 2019). However, not much still examines the learning barriers that students experience and the learning designs that can minimize these obstacles. This phenomenon is not only happening in Indonesia but also abroad. Here are some examples of studies that do not examine this phenomenon. Research in the city of Semarang, Indonesia (Muhtarom et al., 2020) has examined the beliefs of prospective mathematics teachers about solving mathematical problems. The research uses qualitative data analysis, revealing that while students exhibit constructivist beliefs during the problem-solving process, most prospective teachers hold spiritual beliefs about mathematical problems. This research at least provides an overview of one of the research trends in Indonesia.

More broadly, research in Chicago, USA (Jenifer et al., 2022) uses a quantitative approach to examine the relationship between math anxiety and math avoidance by assessing learning strategies and student test scores in calculus courses. The results of the study have revealed several findings. First, the problem-solving strategy has been identified as the most difficult learning strategy. Second, anxiety about learning mathematics has been found to be related to unplanned involvement in problem-solving. Third, the avoidance of students in problem-solving efforts has been identified as partly mediating the relationship between math anxiety and exam performance. Research in Quebec, Canada (Hitt & Dufour, 2021) has examined students' cognitive problems when studying calculus, especially when solving open-ended problems. This research has used a quantitative approach with the type of teaching experiment. The results of this study have revealed that teamwork in learning has been driven by the reconstruction of representations and changes in perspective from divergent thinking related to students' understanding of situations to convergent thinking in providing solutions to problems.

If we analyze more deeply the findings from several previous studies, it becomes clear that these studies do not seem to integrate mobile technology to address the challenges faced by college students. This is noteworthy, considering that all students have smartphones that could serve as valuable tools in their academic activities. Moreover, previous studies have not utilized didactic design research (DDR) as a method to solve research problems, even though DDR is particularly relevant for addressing issues in lectures. This is because DDR offers solutions grounded in the factors contributing to students' learning obstacles.

Based on the previous description, this study aims to find the factors leading to students' math learning challenges and outline the evolved math lecture designs addressing these obstacles. It also depicts their implementation, coupled with reflective insights. The right research design is didactical design research (DDR), which comes up with new ways to teach math by looking at what gets in the way of learning and how to use mobile technology (Cisonni et al., 2023; Marfuah et al., 2022; Ortega-Quevedo et al., 2023).In this study, mobile technology refers to the use of devices such as smartphones in learning. Mobile technology is recommended because it can enhance learning independence and streamline learning activities from start to finish (Capinding, 2022; Ritonga et al., 2024; Sopacua et al., 2020). Moreover, it allows students to solve problems more easily by searching for information online using their smartphones (Bennett et al., 2020). Additionally, all students possess smartphones and are proficient in operating them. Previous studies have also highlighted that mobile technology can optimize students' mathematical competence in higher education. This study uses a lecture design in the form of a hybrid module. From the previous research objectives, several questions are derived, including: (1.1) What is the description of the learning barriers that students experience in mathematics lectures? (1.2) What is the description of the hybrid mathematics lecture module with mobile technology assistance that is used to minimize student learning barriers? (1.3) How is the description of implementing the hybrid mathematics lecture module with mobile technology assistance in class? (1.4) How is the revision of the hybrid mathematics lecture module with mobile technology assistance based on the implementation results in class? (1.5) After introducing the hybrid mathematics lecture module with mobile technology in class, how do the descriptions of learning barriers experience by students in math lectures change?

METHOD

The approach in this study was a qualitative approach to the type of DDR. DDR was chosen because this research aimed to develop alternative lectures to minimize learning barriers experienced by students (Prabowo et al., 2022; Sukarma et al., 2024). The alternative lectures intended in this study were didactic designs for mathematics courses for undergraduate students in agrotechnology and agricultural product technology at a tertiary institution in Mataram, Indonesia. The DDR paradigm was then relevant to the purpose of this study. DDR was based on an interpretive paradigm because it sought to make sense of the learning barriers that students experienced. In the context of this research, this paradigm was implemented by identifying the types of learning barriers that students experienced and the factors that resulted in these learning barriers. DDR was also based on a critical paradigm because it sought to provide alternative solutions in lectures. The practical design for math classes that used mobile technology to help students learn, created after looking at what got in the way of learning, was an example of this critical paradigm in action in this study (Suryadi, 2019b).

As previously described, this

research was conducted at a university in Mataram, Indonesia. The university was chosen because it was classified as one of the famous universities. However, some students needed help with mathematics-related lectures (results of FGDs with several mathematics lecturers). The target participants in this study were students of the Faculty of Agriculture. The faculty was chosen because it had a strict selection procedure for admitting new students. In addition, the faculty also made mathematics a compulsory subject in the curriculum. Using a purposive sampling technique, the participants in this study, originally intended to be 53 students, were narrowed down to 17 students (11 boys and six girls) from the agrotechnology and agricultural product technology study programs. This was because participants were naturally formed into class groups. The participants' ages ranged from 18 to 25 years. During high school, 5 participants majored in natural sciences, and 12 participants majored in social studies. Participants came from two ethnic groups: Sasak (12 students) and Sumbawa (5 students).

The main instrument in this research was the researcher because this research used a qualitative approach (Creswell & Creswell, 2018). Additional instruments in this research activity were a mathematics comprehension test, an in-depth interview guide, and a didactic design in the form of a hybrid module with mobile technology assistance for mathematics courses. This course was chosen because it was a mandatory basic subject and had many roles in the world of agriculture (McKim et al., 2017). The math comprehension test consisted of two math questions compiled by NCTM (NCTM, 2014). The in-depth interview guide used several semi-structured, open-ended questions. Open questions were used to obtain more in-depth information according to the participant's point of view (Brown & Danaher, 2017). The compiled hybrid mathematics lecture module fulfilled the content validity test by 9 experts, namely 7 experts in the field of mathematics education and 2 education experts. Based on the assessment results of nine experts and after analyzing the CVR value (Lawshe, 1975), information was obtained that the CVR value for the mathematics module was 1. In other words, the hybrid module was essential for mathematics lectures. This study used the steps in DDR, namely prospective, metapedadidactic, and retrospective analysis (Marfuah et al., 2022), as shown in Figure 1 (See Appendix A).

In this study, triangulation of data sources was employed to strengthen trustworthiness (Morrison et al., 2019; Richard & Hemphill, 2018). NVivo-12 assisted in the thematic analysis of data pertaining to learning barriers (Sasidharan & Kareem, 2023). The thematic analysis involved familiarizing oneself with the data, finding the initial code, determining themes, reviewing themes, and naming or defining themes (Pigden & Jegede, 2019). A combination of qualitative data analysis and retrospective analysis was also used to look at the outcomes of introducing a mobile technology-based math lecture module (Miles et al., 2014; Suryadi, 2019b).

Qualitative data analysis entailed reducing data, presenting data, and drawing conclusions (Miles et al., 2014). During the data reduction phase, researchers sorted the necessary data by eliminating some less important data for analysis. Subsequently, researchers analyzed the data by assessing the coherence, flexibility, and unity of the didactic situation in the mathematics lecture module (Suryadi, 2019a). Data from the analysis were presented in various forms, such as descriptions, tables, and illustrative images.

Following that, the researcher concluded by revising the mathematics lecture module based on the results of the previous analysis.

RESULTS AND DISCUSSION

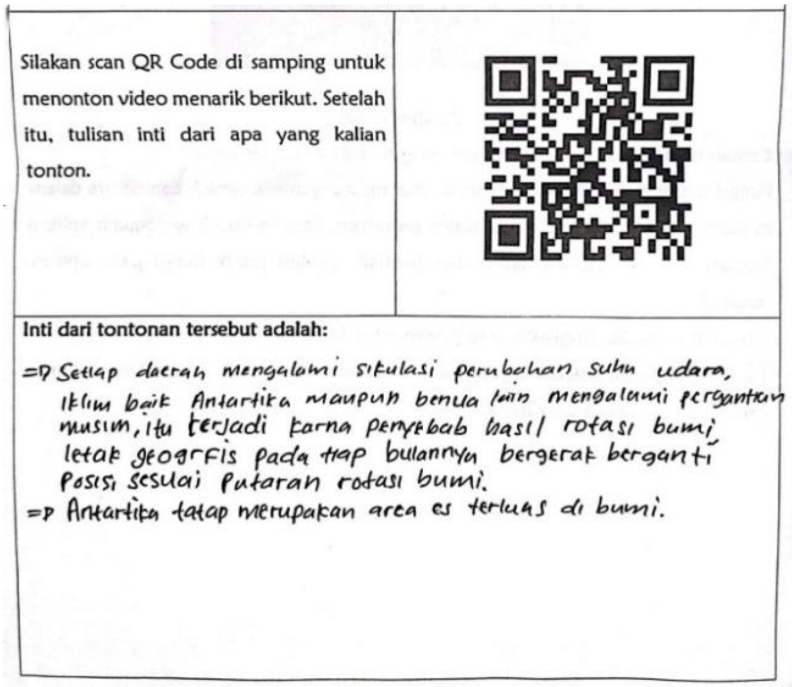
Results

What is the description of the learning barriers that students experience in mathematics lectures?

Based on the results of the NVivo-12-assisted thematic analysis, data was collected on the theme of student learning barriers in math classes, as shown in Table 1 (See Appendix B). After the themes were formed, this study attempted to determine the factors that caused students to experience learning difficulties by conducting in-depth interviews with several students. Concerning T_a, information was obtained from in-depth interviews that indicated that students did not understand the meaning of the questions because they rarely got questions in the form of stories during mathematics learning at school. Regarding T_b, information was obtained that students did not experience learning difficulties. It is because, during in-depth interviews, students can answer according to what is on the answer sheet. The presence of T_d, which confirms the low ability to understand students' pre-requisite material, and the presence of T_c, which confirms that students are not careful in doing their work, can be seen in Table 2. Interview excerpts for the T_c theme can be seen in Table 2 (See Appendix B).

What is the description of the hybrid mathematics lecture module with mobile technology assistance that is used to minimize student learning barriers?

After analyzing the types of student learning barriers, the next activity carried out in this study was the compilation of a hybrid mathematics lecture module. The module was prepared based on the results of the analysis of student learning barriers that were described in the previous section. The alternative solutions offered in the


Silakan scan QR Code di samping untuk menonton video menarik berikut. Setelah itu, tulisan inti dari apa yang kalian tonton.

Inti dari tontonan tersebut adalah:

=> Setiap daerah mengalami sikulasi perubahan suhu udara, iklim baik Antartika maupun benua lain mengalami pergantian musim, itu terjadi karna penyebab hasil rotasi bumi, letak geogrfis pada tiap bulannya bergerak berganti posisi sesuai putaran rotasi bumi.
=> Antartika tatap merupakan area es terluas di bumi.

Figure 3. A snippet of Student Answers for Let's Watch Activities

hybrid mathematics learning module based on analyzing learning barriers can be seen in Table 3. Based on the considerations in Table 3, a mathematics lecture module that integrated these alternatives was developed. Because what was compiled in this study were modules, several activities were added to form a complete learning experience. For more detailed information regarding the hybrid mathematics lecture module, it could be accessed at the following link: https://shorturl.at/nvo69. A complete description of alternative solutions offered by researchers can be seen in Table 3 (See Appendix B).

In addition, the hybrid mathematics lecture module integrated ICT into learning. It combined the use of ICT with presenting the results of working on activities in print. There were several forms of integrating ICT in the module, such as the use of the QR code as a basis for learning activities, the use of online test applications to ensure students understood the prerequisite material, the use of the internet to search for information and find solutions to the problems presented, the use of *Android-based GeoGebra* in the learning process, as well as the use of smartphones as the main tool in carrying out learning.

How is the description of implementing the hybrid mathematics lecture module with mobile technology assistance in class?

In the early lecture activities, as usual, the lecturer opened the class with a greeting and an opening prayer. After that, students listened to the lecturer's explanation regarding the purpose of the lecture. Namely, students were expected to be able to describe functions consisting of one or two independent variables and solve agricultural problems involving equations of linear functions. Students were then asked to complete the *Let's Play* activity by scanning the QR code in the hybrid mathematics lecture module. Snippets of student answer reports for this activity can be seen in Figure 2. Figure 2 also showed that some students did not understand the prerequisite material. However, after being confirmed with students, information was obtained that they experienced problems with the internet connection when playing, so they could not work on the questions properly.

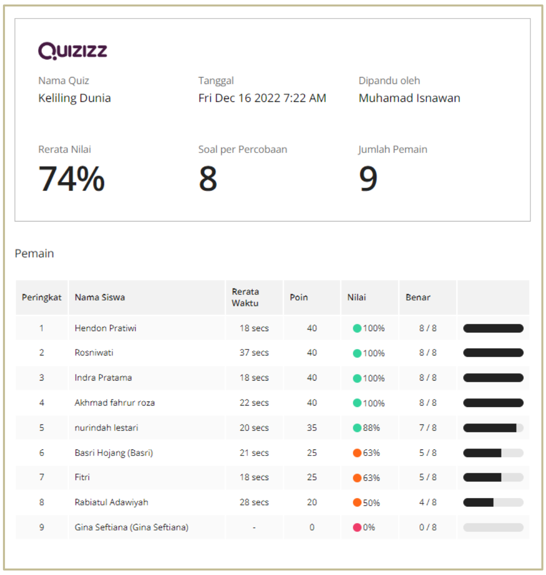
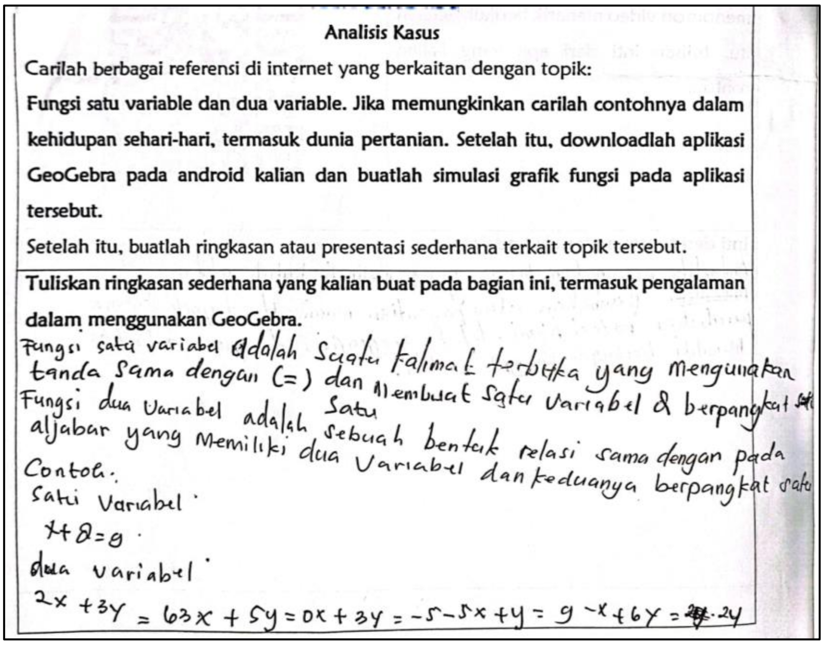


Figure 2. Snippets of Student Answer Reports for Let's Play Activities

In addition, in this activity, there were several obstacles that the researcher found. First, implementing online tests via *Quizizz* required lecturers to be in an online condition, so they required lecturers to also activate *Quizizz* when students were carrying out tests. This automatically made learning less flexible because it had to be done under the guidance of a lecturer. Second, students who experienced internet connection problems could not take or continue the test. Next, students worked on *Let's Watch* activities. In this activity, students were asked to watch videos related to Antarctic conditions, according to NASA. The video was expected to arouse students' interest and


Analisis Kasus

Carilah berbagai referensi di internet yang berkaitan dengan topik:

Fungsi satu variable dan dua variable. Jika memungkinkan carilah contohnya dalam kehidupan sehari-hari, termasuk dunia pertanian. Setelah itu, downloadlah aplikasi GeoGebra pada android kalian dan buatlah simulasi grafik fungsi pada aplikasi tersebut.

Setelah itu, buatlah ringkasan atau presentasi sederhana terkait topik tersebut.

Tuliskan ringkasan sederhana yang kalian buat pada bagian ini, termasuk pengalaman dalam menggunakan GeoGebra.

Fungsi satu variabel adalah suatu kalimat terbuka yang menggunakan tanda sama dengan (=) dan membuat satu variabel & berpangkat satu
Fungsi dua variabel adalah sebuah bentuk aljabar yang memiliki dua variabel dan keduanya berpangkat satu relasi sama dengan pada
Contoh.
Satu variabel
x+8=9
dua variabel
2x + 3y = 6 3x + 5y = 0 x + 3y = -5 -5x + y = 9 -x + 6y = [illegible] 24

Figure 4. Snippets of Student Answers for Let's Discover Activities

motivation to start lectures and inspire them to realize the uniqueness of Antarctica from a mathematical point of view. Figure 3 shows snippets of student answers for the *Let's Watch* activity. In essence, students in this activity could do the activity very well. There was one obstacle to this activity, such as the fact that the time used by students tended to be more than allocated because there was no limit to the answers students could give.

The lecture activities were then continued with *Let's Discover* activities. In this activity, students used smartphones to find as much information as possible via the internet to solve problems presented in the hybrid mathematics lecture module. Figure 4 provides examples of student answers in the *Let's Discover* activity. Students were able to do this activity well. Students were able to install *GeoGebra* on their respective smartphones and simulate graphing functions on the application. Based on the results of observations during lectures, collaboration between group members and complete information on the internet helped the students solve the problems well. A snippet of student answers for this activity can be seen in Figure 4.

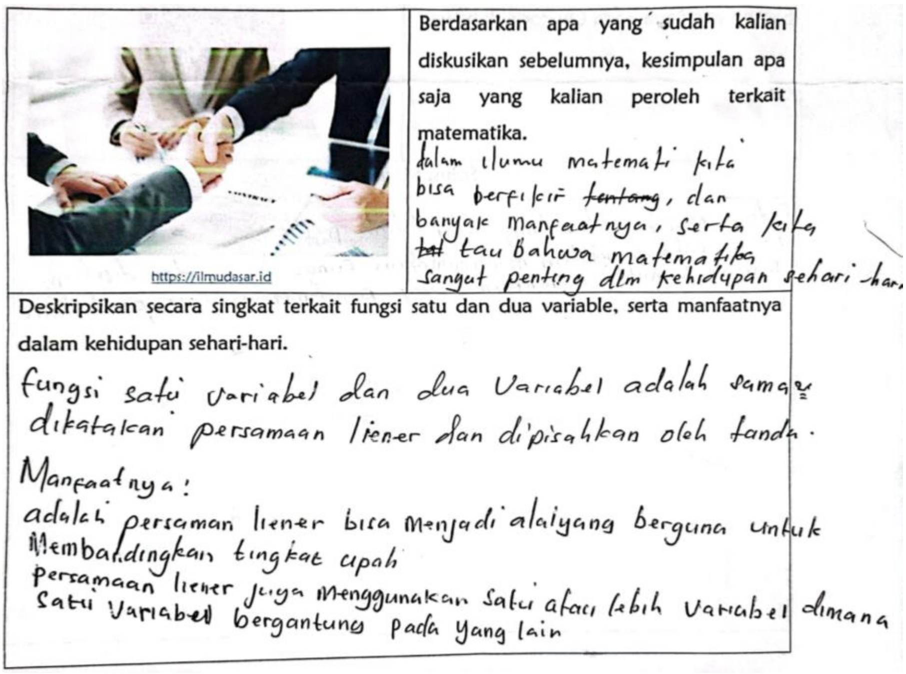
There were several obstacles experienced by students in *Let's Discover* activities, such as students not dividing tasks when looking for information so that work results were less effective and efficient; the information obtained by students tended to be conceptual yet, so lecturers had to give them reinforcement; and students did not know how to make graphic simulations on *GeoGebra.* However, the main obstacle to this activity was the allocation of learning time, which tended to be mostly spent on this activity. The next activity was *Let's Present.* In this activity, there was a discussion between groups of students when presenting their work. Each group responded to the other groups. Although there were also some obstacles experienced in this activity, such as several groups having difficulty determining group presenters, the responses from one group to another group still did not lead to a conceptual conclusion. In addition, pointing fingers between group members as presenters tended to occur during presentation activities. Documentation of this activity can be seen in Figure 5.

Figure 5. Snippets of Student Answers for Let's Present Activities

After each group presented their work results, students concluded the concept of the function of one and two variables and the benefits of functions in everyday life. Figure 6 provides information on student answers in the *Let's Summarize* activity. In this activity, the main obstacle was that students seemed unable to correctly conclude the function of one and two variables. Therefore, the lecturer validated it by saying that a *variable y* is a function of the *variable x* if *x* and *y* have certain rules that state the relationship between *x* and *y* so that for each *x* value, it is possible to have a *y* value.

The next activity was *Let's Institutionalize*. In this activity, students were asked to summarize an article containing a linear function consisting of several variables. Unfortunately, students in this activity might not have done it optimally. This was due to the time allocation, which tended to be considered insufficient. A snippet of student answers can be seen in Figure 7.

Finally, students conducted reflection activities on the concepts obtained and the learning process. Students in this section revealed that they felt happy learning in this lecture and looked wrong


https://ilmudasar.id

Berdasarkan apa yang sudah kalian diskusikan sebelumnya, kesimpulan apa saja yang kalian peroleh terkait matematika.

dalam ilumu matemati kita bisa berfikir ~~tentang~~, dan banyak manfaatnya, serta kita ~~tat~~ tau Bahwa matematika sangat penting dlm kehidupan sehari-hari.

Deskripsikan secara singkat terkait fungsi satu dan dua variable, serta manfaatnya dalam kehidupan sehari-hari.

fungsi satu variabel dan dua Variabel adalah sama dikatakan persamaan liener dan dipisahkan oleh tanda.

Manfaatnya:

adalah persaman liener bisa menjadi alaiyang berguna untuk Membandingkan tingkat upah

persamaan liener juga menggunakan satu atau lebih Varabel dimana satu Variabel bergantung pada yang lain

Figure 6. A Snippet of Student Answers for Let's Summarize Activities

in expressing appropriate concepts. The lecturer then confirmed the students' answers, and the students revised their previous answers. Researchers learned crucial information from this activity, namely that students responded favorably to the hybrid mathematics lecture module's teaching methods. According to some students, the lectures seemed different from other lectures, students became happier and more motivated during lectures, and students considered that the discovery of basic concepts was important to emphasize during module work. Figure 8 provides snippets of student answers in the *Let's Reflect* activity.

Figure 8. A Snippet of Student Answers for Let's Reflect Activities

How is the revision of the hybrid mathematics lecture module with mobile technology assistance based on the implementation results in class?

Based on the description in the previous section, students experienced several obstacles during learning activities. *Let's Play* activities required lecturers to be online when working on test questions, internet connections were sometimes problematic, time allocations tended to be more than they should be, there were no character limits for student answers for each activity, students were less able to divide assignments when searching for information on the internet, the information provided by students was not conceptual, they did not know how to make graphical simulations on *GeoGebra*, students were still confused in determining the presenter of the results of group work, the responses given by students were still general, the conclusions given by students were still general, student answers for *Let's Institutionalize* activities were still general, and certain QR codes did not access the right file.

Based on these constraints, there were several revisions to the hybrid mathematics lecture module. This revision was expected to be an alternative solution for the next lecture. It could train educators so that they did not feel that the learning design was perfect enough that it did not require future improvements. These revisions can be seen in Table 4.

After introducing the hybrid mathematics lecture module with mobile technology in class, how do the descriptions of learning barriers experienced by students in math lectures change?

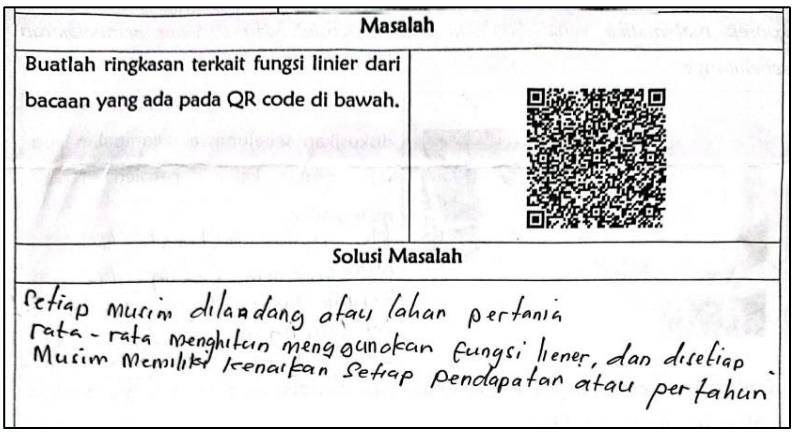


Figure 7. A Snippet of Student Answers for Let's Institutionalize Activities

Based on the description of the obstacles during implementation, it can be concluded that students were not indicated to experience learning obstacles such as those described in the second question, as explained in the previous point (the first research question). This was because during the implementation, the students were able to answer the questions according to what the researcher expected. In addition, students appeared to be more careful when solving problems, even though time constraints still prevented them from doing so. However, the design was what caused this issue. The instructions in the design were less operational, so it directed students to work without character limits and resulted in excessive time allocation. In other words, one form of obstacle that students experienced tended to be technical or instrumental matters during lectures.

Table 4. Revision of the Hybrid Mathematics Lecture Module

Experienced Obstacles	Design revision
Let's Play activities require lecturers to work online on test questions.	There are no revisions to the module. Lecturers in this activity are expected to ensure that the online test application is ready before learning begins.
An Internet connection sometimes has problems.	There are no revisions to the module. Lecturers make sure students have their own data plan that will be used when encountering internet connection problems on wifi.
Time allocation tends to be more than it should be.	Limit the number of answer characters or the number of student paragraphs for each activity.
There is no character limit for student answers for each activity.	
Students are not sure how to use *GeoGebra* to simulate a graph.	
Students are less able to divide tasks when searching for online information.	In the *Let's Discover* activity, the researcher added instructions to the module by "dividing tasks in finding information on the internet when solving problems, including presenters."
The information provided by students is not yet conceptual.	Added guide editor to the module by "focus on searching using keywords that match the problem" and added scaffolding to the Come on Find activity.
Students are still confused in determining the presenter of the group work results.	In the *Let's Present* activity, the researcher added instructions to the module by "choose one of the group members as the presenter."
The responses given by students are still general.	Added redaction instructions to the Come on Presents activity with a "focus on providing responses related to the problem being solved."
The conclusions given by students are still general.	Adding trigger questions so that student answers become more focused.
The students' answers for the *Let's Institutionalize* activity were still general.	
Certain QR code is not accessing the right file.	Provides document links in modules.

Discussion

What is the description of the learning barriers that students experience in mathematics lectures?

If it is associated with theories related to the types of learning barriers (Brousseau, 2002; Prabowo et al., 2022), then students experience learning barriers with ontogenic obstacles that are psychological (not careful in doing) and conceptual (lack of mastery of the prerequisite material). Not being careful in working on the context of this study refers to students tending to be in a hurry when working on it. This action then causes the student's answer to be wrong. This action also occurs not just once but several times, thus requiring special intervention in lectures. If allowed to drag on, it impacts student learning outcomes that are not optimal. What's more, if the questions that students must solve are multiple-choice, it indicates that students who experience learning difficulties will not find the right answer. When what is done is a description question, it affects the student's answer in the next step. The illustration is that when students are not careful when writing down questions to be answered, all student answers will automatically be wrong. This study's results align with the theory and several previous studies that reveal that students' carelessness negatively impacts mathematics learning outcomes (Isnawan, 2022; Makonye & Khanyile, 2015).

Furthermore, students' lack of understanding regarding prerequisite material is a problem often found in the context of lectures. One of the properties of mathematics is procedural. In other words, when someone does not master the previous concept (prerequisite material) in mathematics well, they are likely less able to master the next concept that requires the prerequisite material (Deeken et al., 2020). The results of this study are in line with this theory and with several previous studies that revealed that students' common knowledge of prerequisite material is one of the obstacles experienced in learning mathematics (Hasibuan et al., 2018; Makhubele, 2021).

If it is related to the theory of learning barriers (Brousseau, 2002; Prabowo et al., 2022; Puspita et al., 2023), information is obtained that students are indicated to experience learning barriers with this type of epistemological obstacle because when learning about rational numbers in schools, mathematics teachers in schools use limited contexts and rarely use illustrative models. This, in turn, impacts the lack of students' collaboration skills during lectures. This type of learning barrier is a learning obstacle that is important enough to get the attention of educators or researchers in mathematics education. This is because epistemological obstacles are obstacles that directly affect the processes that occur in learning (Elias et al., 2018).

A student may have a negative interest or attitude toward mathematics because of this learning barrier. In addition, mathematics, which is apriori (Palmquist, 1987), also forces learning barriers of this type not to appear in the learning context. This is because mathematics studied anomalies and the mathematical nature of a priori knowledge as if it were a posteriori knowledge (Palmquist, 1987). This posterior form then forces mathematics to begin to be studied by presenting problems in everyday life or operational problems to achieve a priori mathematics. The results of this study are also in line with several previous theories and studies that reveal that epistemological obstruction is one of the dominant types of learning barriers that cause students to experience obstacles in learning mathematics (Isnawan, 2022; Prabowo et al., 2022). Having identified the barriers students face in mathematics lectures, the next section examines how the hybrid module was designed to address these challenges.

What is the description of the hybrid mathematics lecture module with mobile technology assistance that is used to minimize student learning barriers?

The hybrid module is an alternative solution (Lumbantoruan & Ditasona, 2024) because, based on several theories and the results of previous research, it is concluded that learning that combines ICT with manual work will positively impact the quality of learning and student competence (Ammy & Maryanti, 2023;

Dockendorff & Solar, 2018; Fathiyyah Firdaus & Marina Angraini, 2023; Tossavainen & Faarinen, 2019). There are several reasons for using ICT in the module, such as all students having smartphones that can be connected to the internet, QR codes tend to be effective and efficient in accommodating activities in learning, and online test applications arouse student interest and motivation in learning (Bennett et al., 2020; Santagata et al., 2021; Tomar et al., 2024; Tossavainen & Faarinen, 2019). The application challenges students to compete with other students in learning activities.

Apart from that, the hybrid mathematics lecture module is structured based on didactic situation theory. This theory divides learning activities into action situations, formulation, validation, and institutionalization (Brousseau, 2002; Suryadi, 2019a). In action and formulation situations, students are asked to solve problems using all the information available on the internet. After the problem is solved, students enter a validation situation, namely, a situation where they present the results obtained with the aim of validating the answers they have. After the answers are validated, students enter an institutionalization situation, namely a situation where they use the concepts, they have discovered to solve other problems presented in the module (Suryadi, 2019b). This kind of learning pattern can then be called an epistemic lecture pattern because it is able to facilitate students in constructing concepts based on physical and mental activities during lectures (Isnawan, 2022; Sukarma et al., 2024). Ultimately, these activities aim to reduce students' learning barriers, allowing their mathematical competence and collaboration skills to develop optimally. To demonstrate this, the next section explains the implementation of the hybrid mathematics module.

How is the description of implementing the hybrid mathematics lecture module with mobile technology assistance in class?

Based on the research results described previously, it is known that several responses are given by students during the implementation of the hybrid mathematics lecture module. Figure 2 shows that most students can know the prerequisite material well so that lectures can be continued in the next activity. These results are based on theory and previous research revealing that learning activities can be continued when students understand the prerequisite material is sufficient (Hasibuan et al., 2018; Makhubele, 2021). Figure 2 also shows that some students do not understand the prerequisite material. However, after being confirmed with students, information is obtained that they experience problems with the internet connection when playing, so they cannot work on the questions properly.

During the *Let's Play* activity, students experience technical problems while answering test questions. This result also aligns with (Isnawan, 2022), which reveals a tendency for students to experience technical problems during learning that hinder the learning process itself. There is one obstacle to the *Let's Watch* activity, such as the fact that the time used by students tends to be more than allocated because there is no limit to the answers students can give. This study's results align with the theory and several previous studies that reveal that student-centered learning tends to take longer than it should (Bremner et al., 2022; Emaliana, 2017). Based on the results of observations during *Let's Discover* activities, collaboration between group members and complete information on the internet make the problems solved by students quite well. These results are in line with theory and some previous research, which reveals that social interaction in groups would help students solve a problem, and the use of ICT would make it easier for students to obtain information or strategies needed to solve problems (Topciu & Myftiu, 2015; Tossavainen & Faarinen, 2019).

Furthermore, in the *Let's Present* activity, there are some obstacles experienced, such as several groups having difficulty determining group presenters, and the responses from one group to another group still do not lead to a conceptual conclusion. This study's results align with the theory and several previous studies, which reveal that in discussion activities, not all students can provide good responses (Ahmad, 2021; Sjöblom et al., 2022). In addition, pointing fingers between group members as presenters tends to occur during presentation activities. Students tend to lack confidence in learning activities (Ahmad, 2021). Like the previous activity, in the *Let's Summarize* activity, the main obstacle is that students seem unable to correctly conclude the function of one and two variables. Therefore, the lecturer validates it by saying that a variable y is a function of the variable x if x and y have certain rules that state the relationship between x and y so that for each x value, it is possible to have a y value. It is important to note that during the validation phase, the lecturer must provide directed feedback carefully. This ensures that the concepts developed by students reach the scholarly knowledge stage. This study's results align with the theory and several previous studies, which reveal that educators have a very important role in providing conclusions when students tend to be less than optimal or not completely correct in concluding the concepts found (Koskinen & Pitkäniemi, 2022; Lodge et al., 2018).

The next activity is *Let's Institutionalize.* In this activity, students cannot do it optimally. This is due to the time allocation, which tends to be considered insufficient. These results align with theory and previous studies, which reveal that students tend to be less able to implement concepts obtained in learning in contexts, situations, and conditions that are different from before, especially when it involves problems of everyday life (Hartmann et al., 2021; Pongsakdi et al., 2020). The last activity is my reflection. Students in this section reveal that they feel happy learning in this lecture. The results of this study are in line with the theory and several previous studies that reveal that student-centered learning and using ICT tend to get positive responses during learning activities (Dockendorff & Solar, 2018; Tossavainen & Faarinen, 2019).

How is the revision of the hybrid mathematics lecture module with mobile technology assistance based on the implementation results in class?

As previously described, there were several obstacles experienced during lectures. This revision is expected to be an alternative solution for the next lecture. It can train educators so that they do not feel that the learning design is perfect enough that it does not require future improvements. Ideally, reflecting on learning activities is mandatory for educators to carry out during learning (Muchlis et al., 2020). If possible, three types of reflection will be conducted: reflection on learning, reflection during learning, and reflection on learning (Ghorbanpour et al., 2021). The results of this research are then in line with several previous studies (Fitriati et al., 2023; Joubert et al., 2020), which revealed that redesigning learning designs through reflection activities is a necessity for educators so that the quality of learning in the future will be better.

After introducing the hybrid mathematics lecture module with mobile technology in class, how do the descriptions of learning barriers experienced by students in math lectures change?

As described in the research results section, students indicate that they do not experience learning obstacles as in *Research Question 1.* However, students indicate that they experience obstacles with the instrumental ontogenic obstacle type because there are several instructions that are lacking in the learning design so that the answers that students give are less than optimal and this results in excessive learning time. Yet, according to several previous theories and research (Capinding, 2022; Sopacua et al., 2020), instructions in modules play a crucial role in enabling students to learn independently when using learning modules. When related to the theory of learning obstacles (Brousseau, 2002; Prabowo et al., 2022), students are indicated to be experiencing instrumental ontogenic obstacles after the implementation of the hybrid mathematics lecture module with mobile technology assistance. This is due to the presence of incomplete instructions in the module. This research aligns with several previous theories and studies (Isnawan, 2022; Marfuah et al., 2022) that revealed instrumental ontogenic obstacles as one of the common types of obstacles that arise, especially when analyzing teaching materials or instructional design. This is because there is no perfect design in education.

Implication of Research

This research recommends that math educators integrate ICT tools into instruction. Online tests add depth, videos boost motivation, QR codes streamline, and problem-based learning enriches dynamics. The future study invites researchers to explore intricate didactic interplay, spotlighting validation and institutionalization phases for future inquiries. In addition to mathematics educators in higher education, the results of this study are also expected to be applicable to other STEM disciplines. This aims to evaluate the broader impact of the hybrid module on improving learning outcomes.

Limitation

This research had several limitations. First, the researcher did not prepare a laptop that was on standby for the *Let's Play* activity before the lecture. Second, the researcher did not prepare equipment that would help students in making presentations, such as cardboard and colored markers that students could use in carrying out the *Let's Discover* activity. In addition, this study was conducted in a single institutional context, which limited the generalizability of the findings to other cultural or educational settings.

CONCLUSION

Based on findings, there are some conclusions of this research. Students presently grapple with math learning obstacles ranging from inattentiveness to methodological nuances (psychological ontogenic) to struggling with core concepts, especially rational number operations (conceptual ontogenic). Contextual constraints and illustrative models further impede mathematics progress (epistemological hurdle). A hybrid math module, combined with mobile technology, features interesting, sequenced activities. Mobile technology (online tests, educational videos, and QR codes) inject innovation. Activities align with learning stages, weaving didactic scenarios for holistic understanding. Most activities function well, with ongoing refinements based on implementation outcomes. The hybrid module addresses ontogenic obstacles but introduces didactic challenges due to unclear scaffoldings. Students battle understanding and applying new math concepts in problems, traced back to inadequate validation. This affects institutionalization phase. The study advocates systematic didactic phases. In short, the hybrid mathematics lecture module can minimize learning obstacles that students experience during lectures. The hybrid mathematics lecture module is then included in the epistemic learning pattern because it can construct knowledge through various mental and physical activities.

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Appendix A of article entitled Exploring the Use of Mobile Technologies in Indonesian Mathematics Lectures

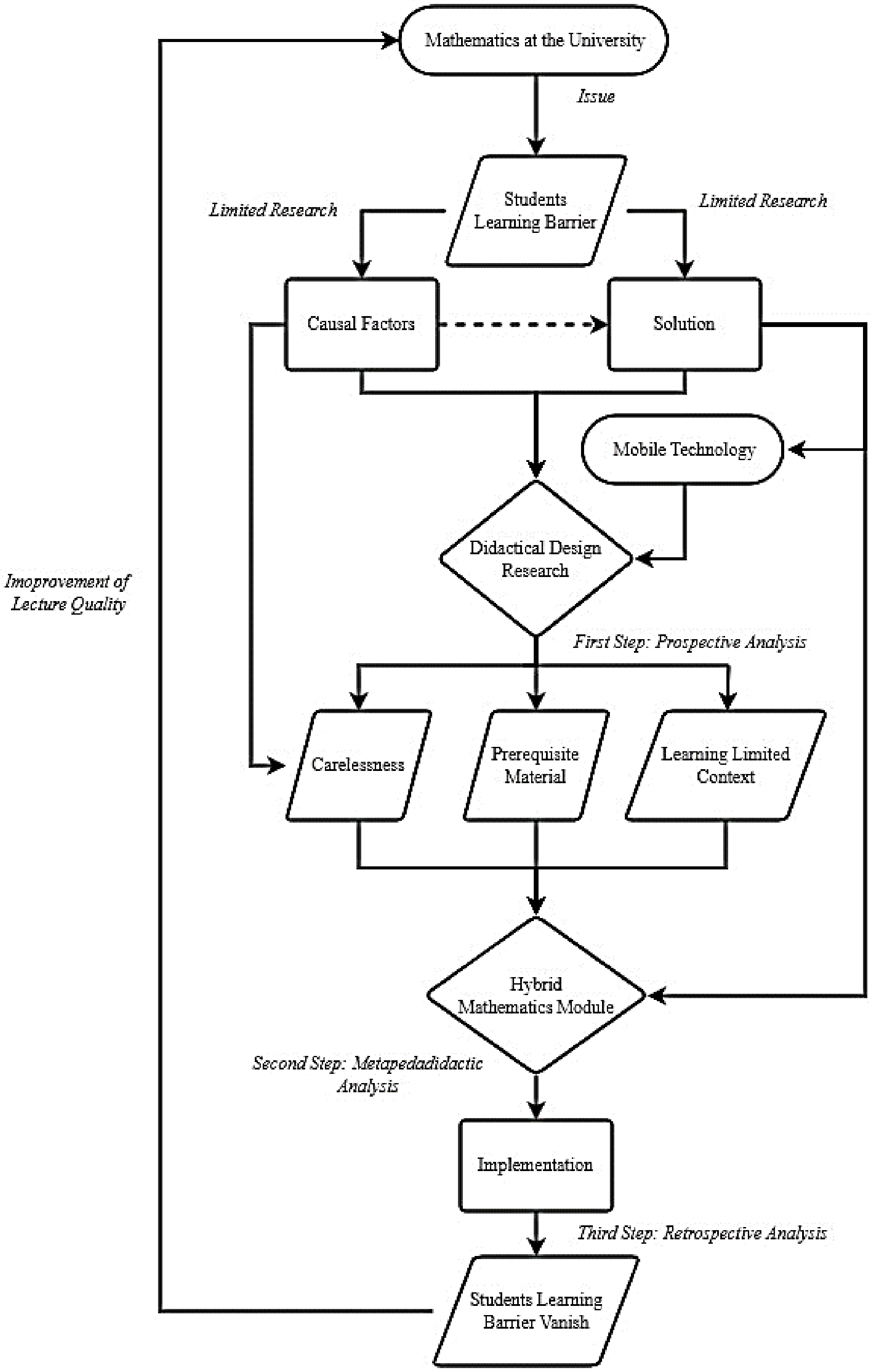

Figure 1. Research Procedure

Appendix B of article entitled Exploring the Use of Mobile Technologies in Indonesian Mathematics Lectures

Table 1. Student Learning Barriers Theme

Initial Code	Theme	References
Students are less able to make mathematical modeling (subtraction). Students have a lower ability to perform mathematical modeling (division). Students are less capable of developing mathematical models (addition). Students have a lower ability to perform mathematical modeling (percentage).	T_a (student made a mistake in making a mathematical model).	9
Students face no difficulties.	T_b (Students face no difficulties).	7
Students are less able to add rational numbers. Students have a lower ability to multiply rational numbers. Students make mistakes when operating with integers.	T_c (students are wrong in operating numbers).	5
Students are wrong in determining the number equivalent to certain rational numbers. Students make a mistake when converting rational numbers to decimal form.	T_d (student wrong in equating rational numbers).	4
Students skip several steps of the process.	T_e (students are not careful in doing).	1

Table 2. Snippets of In-depth Interviews with Several T_c Students

Researcher Questions	Participant Answers
Did you notice your mistake when operating on numbers for this section?	*P1: Wrong sir.*
Where is the error?	*P2: I realize it.*
What is the reason you realize it now?	*P1: I used the rational number multiplication method, which is not right.*
What about the equivalence of rational numbers?	*P2: I should have multiplied the quantifier and denominator.*

Table 3. Alternative Solutions Offered in the Hybrid Mathematics Lecture Module

Learning Barriers	Alternative Solutions
Students are not careful in doing this.	Add instructions as reminders for students to do activities in the module carefully, pay attention to the time allocation for the work, and ask students to check their answers before presenting or submitting.
Students do not master the prerequisite material.	Several questions are given to students during the early lecture activities to ensure mastery of the prerequisite material.
There are limitations to the context that educators use.	Present various contexts in the form of problems that students must solve and utilize ICT to solve the problems presented.