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Didactic Design Research Through Lesson Study Activities: STEM-Based Courses for Representative Abilities of Prospective Mathematics Teachers

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ABSTRACT

Many studies have examined representational abilities, but few have explored the use of lesson study activities based on didactical design research, which integrated STEM to solve problems in higher education. This research aimed to develop a STEM-based blended lecture design that optimized the representation abilities of prospective mathematics teachers. Conducted as didactical design research, the study employed lesson study activities. Participants included 29 prospective mathematics teachers (aged 18–21 years, 22 women and 7 men) at a private university in Mataram, Indonesia. The primary tool was the researcher, with biodata questionnaires, performance tasks, observation sheets, blended lecture designs, and video recordings serving as supplements. Qualitative data analysis was applied to scrutinize the gathered data. The results of the study revealed that the initial representation ability of mathematics was quite low, so a STEM-based blended lecture design was created to optimize students' representation abilities. Ultimately, the implementation of the design was able to optimize students' representation abilities. This occurred because the design facilitated students in using STEM to solve problems by exploring ideas. The research recommended that lectures should integrate STEM to optimize the representational abilities of prospective teachers.

Keywords: blended lecture design, didactical design research, representational abilities, STEM

INTRODUCTION

Representational ability in the context of this research refers to a person's ability to describe or present information verbally, symbolically, physically, contextually, and visually (Putra et al., 2023; Setiawan, 2022). In the context of mathematics education, representation skills are an important skill that everyone must possess (Khairunnisak et al., 2021; Takaria et al., 2020; Tashtoush et al., 2024), including prospective mathematics teachers, because they can help individuals understand and solve mathematical problems more effectively (Sari and Rosjanuardi, 2018). Apart from that, representational abilities also play an important role in facilitating communication between individuals in a mathematical context (Goldin, 2020). A mathematics teacher who has

Table 1. Differences between current research and previous research

Research article	Mathematical ability	Material learned	Research design	Research activities	Media
Arefaine et al. (2022)	Mathematical representation	Calculus	Quasi-experimental design	-	*GeoGebra*
Lusiana and Ningsih (2018)	Mathematical representation	Definite integral	Quasi-experimental design	-	*Maple*
Büchele and Feudel (2023)	Mathematical competencies (modeling, reasoning, and representation)	Mathematics (arithmetic, algebra, functions, and calculus)	Survey	-	-
Ningtyas et al. (2019)	Representational ability	Calculus	Qualitative descriptive	-	-
Supriadi and Ningsih (2022)	Mathematical representation	Probability distribution	Quantitative descriptive	-	-
Current research	Mathematical representation	Learning design	Didactical design research	Lesson study	STEM

good representation skills can communicate more effectively with students, explain concepts clearly, and facilitate in-depth discussions (Mainali, 2021).

Several previous studies, such as those by Arefaine et al. (2022) and Lusiana and Ningsih (2018), have investigated the representation abilities of prospective mathematics teacher. Additionally, Büchele and Feudel (2023) have used regression analysis to assess the increase in process competence, including students' representational abilities in solving exam questions. Furthermore, research conducted by Ningtyas et al. (2019) used a qualitative descriptive research design approach to describe the representational abilities of prospective mathematics teacher in Surabaya, Indonesia. The results of the research show that students were able to present their ideas in a multi-representational manner when solving calculus problems. Similar research was conducted by Supriadi and Ningsih (2022), who adopted a qualitative descriptive research design to describe the mathematical representation abilities of prospective mathematics teacher in Palembang, Indonesia, especially on probability distribution topics.

Although many researchers have investigated the improvement of the representational abilities of prospective mathematics teachers, in-depth research on enhancing representation skills through lesson study activities based on didactical design research that integrates science, technology, engineering, and mathematics (STEM) remains limited. In contrast to several previous studies that focus more on describing students' representational abilities, this research focuses on preparing a course design that optimizes students' representational abilities. The STEM-based lecture design is prepared through lesson study activities based on didactical design research, aiming to make lectures more effective and efficient (Deeken et al., 2020; Fitriati et al., 2023; Marfuah et al., 2022; Nursyahidah et al., 2023; Sukarma et al., 2024). In summary, the differences between current research and previous research are shown in **Table 1**.

Furthermore, the lecture design prepared in this research is a blended lecture design that integrates STEM during lectures, incorporating tools such as QR codes, learning videos, and online test applications like *Quizizz* (Altunışık et al., 2023; Hainey et al., 2020; Isnawan and Alsulami, 2024; Rabu et al., 2019; Santagata et al., 2021; Sudirman et al., 2023; Zainudin and Zulkiply, 2023). Apart from that, the course chosen in this research is the *didactical design research* course, as it is one of the courses related to how to prepare learning designs. Several research questions to achieve the previous research objectives are as follows:

RQ1: What are the initial conditions of students' representation abilities before implementing the STEM-based blended lecture design?

RQ2: What is the form of the STEM-based blended lecture design used to optimize students' representation abilities?

RQ3: How is the process of implementing lectures using the STEM-based blended lecture design described?

RQ4: What are the conditions of students' representation abilities during the implementation of the STEM-based blended lecture design?

RQ5: What is the form of the redesign of the STEM-based blended lecture design after its implementation?

METHOD

Research Design

The research employed didactical design research. This design was used because the research aimed to develop a lecture design aligned with students' characteristics or needs (Sukarma et al., 2024; Suryadi, 2019b, 2019a). To enhance the design, lesson study activities involving multiple lecturers in plan, do, and see actions were utilized.

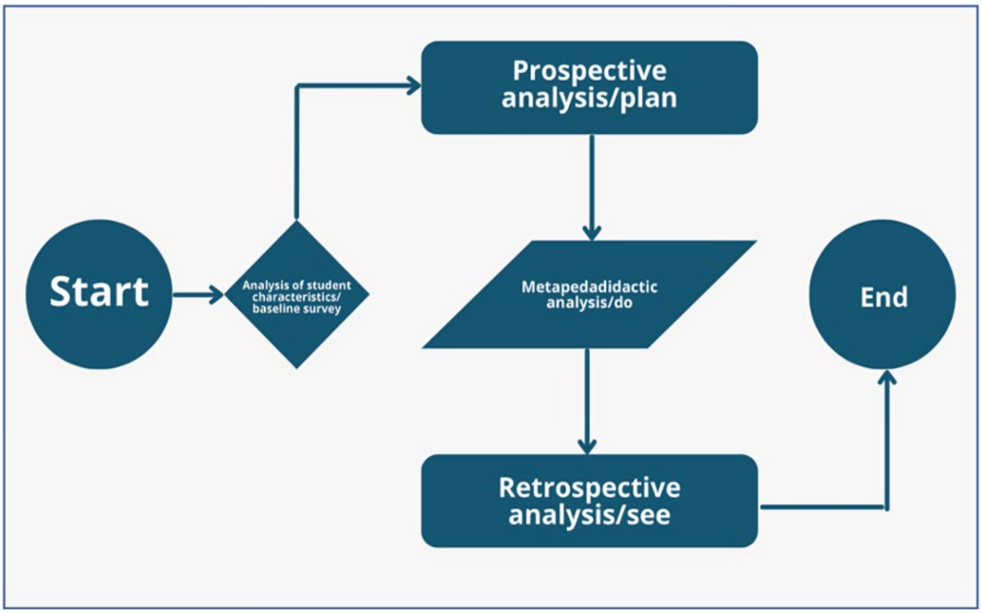


Figure 1. Data collection procedure

Lesson study activities were used because they were able to provide various points of view on the design so that the design became more efficient in presentation (Fitriati et al., 2023; Haryoto and Narimo, 2013; Nursyahidah et al., 2023; Thobela et al., 2023). The research focused on evaluating students' representational abilities to identify effective characteristics of a good mathematics learning design.

Participants

Participants in this research were 29 prospective mathematics teachers at a university in Mataram, Indonesia. These students were selected using purposive sampling on the grounds that they were attending lectures for the *didactical design research* course. In addition, the participants were classified as students with good mathematical abilities, but they were indicated to have been less able to convey ideas well. The age range of participants ranged from 18 to 21 years; there were 22 female students and 7 male students, and most students had hobbies like watching, reading, writing, and drawing.

Instrumentation

The researcher served as the main instrument in this study because it was qualitative research (Creswell and Creswell, 2018), with the assistance of a variety of tools, including student biodata questionnaires, performance tasks, student activity observation sheets, blended lecture designs, and lecture video recordings. The student biodata questionnaire collected information on students' age, gender, hobbies, and aspirations for their favorite lectures. Performance tasks gauged data on students' representational abilities, while the student activity observation sheet documented noteworthy student activities or responses during lectures. The performance task used referred to two problems given by the lecturer during the lecture activities. The problems were related to student performance in designing mathematical learning and how students implemented the design in the form of learning simulations. A STEM-based blended lecture design and video recordings were utilized to capture data on student performance and activities during lectures, respectively. This design could be accessed on the following page: a STEM-based blended lecture design.

Data Collection Procedure

The data collection procedures in this study adhered to the didactical design research stages. In the initial stage, prospective analysis, the researcher collaborated with three other lecturers to scrutinize students' characteristics and needs, including hobbies and expectations for their favorite lectures. Following this analysis, a plan in the form of a blended lecture design was prepared collectively, with one lecturer chosen as the model. The next stage, metapedadidactic analysis, involved other lecturers with student activity observation sheets observing the model lecturer as she delivered offline lectures using the blended design. Concurrently, one lecturer recorded lecture videos. The final stage, retrospective analysis, consisted of the model lecturer sharing experiences and receiving suggestions from observers, which informed revisions or redesigns of the blended lecture design (Fitriati et al., 2023; Marfuah et al., 2022). Refer to **Figure 1** for more details.

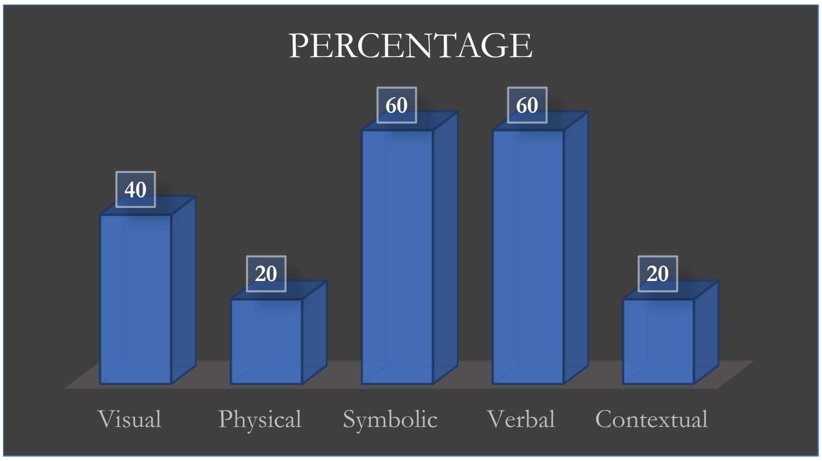


Figure 2. Percentage of student representational ability

Data Analysis Procedure

The data collected in this study underwent qualitative analysis. The analysis comprised three stages: data reduction, data display, and drawing conclusions. During data reduction, unnecessary segments, like unclear video snippets of student activities, were excluded. The subsequent stage involved displaying the data through tables, figures, and concise descriptions. Finally, conclusions were drawn by connecting research results with objectives or questions, highlighting the researcher's role in synthesizing findings. This process involved a meticulous examination of the data to derive meaningful insights and establish connections between the research outcomes and the initial research goals (Miles et al., 2014).

RESULTS AND DISCUSSION

Results

RQ1: What are the initial conditions of students' representation abilities before implementing the STEM-based blended lecture design?

Before designing a STEM-based blended lecture design, researchers first evaluated students' representation abilities through a performance task. The analysis in **Figure 2** showed that the majority of students (60%) were not yet optimal in their mathematical representation abilities. Only 40% could do it visually, while only 20% could do it physically and contextually. The percentage indicates that most prospective mathematics teachers are unable to represent in physical and contextual forms. In other words, students are unable to convey ideas or concepts physically and contextually. In addition, most students are also unable to convey ideas or concepts in visual form, while a small number of others are also unable to convey ideas, either symbolically or verbally.

RQ2: What is the form of the STEM-based blended lecture design used to optimize students' representation abilities?

Based on the previous explanation, it appears that students' representation abilities have not yet reached their peak. Therefore, a course design was needed that could improve this ability. As a follow-up, researchers interviewed five students to find out the factors that hindered their representation abilities. Information from informants highlighted the lack of opportunities for exploring ideas and solving problems in existing lectures. The results of the interview with one of the students can be found in **Table 2**.

The researcher, after analyzing the interviews, formulated a STEM-based course design that would allow students to actively participate in completing case studies to develop ideas. The use of QR codes, inspirational learning videos, and online tests were integrated innovations in this blended lecture design. QR codes made it easier to access various lecture activities, including watching learning videos that aimed to motivate students with moral messages and practical examples that they could follow. Online tests use platforms such as *Quizizz* to assess students' understanding of prerequisites regarding the material to be studied. The goal of this test was to maintain student interest and involvement. This design was chosen because of the ease of access via smartphones that all students had during lectures. Some excerpts of the blended lecture design can be seen in **Figure 3**, **Figure 4**, and **Figure 5**.

Table 2. Excerpts from student interviews

Researcher questions	Student answers
How is your study process going so far?	What do you mean by process?
Yes, your study process. Please tell us a little about the process.	Yes, we attend lectures as usual. The lecturer usually shows PowerPoint slides, and then we are invited to ask questions if there is anything unclear. Sometimes we are asked to answer questions, then we discuss the answers. Just that.
OK, fine. What do you think about a lecture like that?	Yes, that's it, sir.
So how? Is there something missing or what?	There is, sir.
What do you think?	Yes, it's not very interesting, sir. We feel less enthusiastic about studying.
So, do you have any suggestions to make it more interesting?	Hmmm. What is it?
What are you trying to think about?	We discuss this frequently with friends. It's good if college gives you more opportunities to express your opinion.
Have you not been given the opportunity to express your opinion before?	Even though there is, it feels lacking. If possible, we would like a case study to be completed and presented.

Figure 3. Excerpt from a case study on STEM-based blended didactic design

RQ3: How is the process of implementing lectures using the STEM-based blended lecture design described?

After designing the STEM-based blended lecture design, the researcher chose the lecturer as a model to organize and simulate activities. Then, the lecturer led the lecture class according to plan, starting with a speech and prayer. Before continuing, students read the class agreement. In the next step, students conveyed the objectives of the lecture. BK (student 1) explained that the goal was to understand mathematics learning designs that are able to inspire motivation and problem-solving. This aimed to ensure that students knew the final target of learning. After that, they scanned the QR code on the blended design to watch an inspirational video that aimed to motivate consistent good deeds that, even though they are small, have a big impact on themselves and others.

Figure 4. Footage of watching activities in a blended didactic design based on STEM

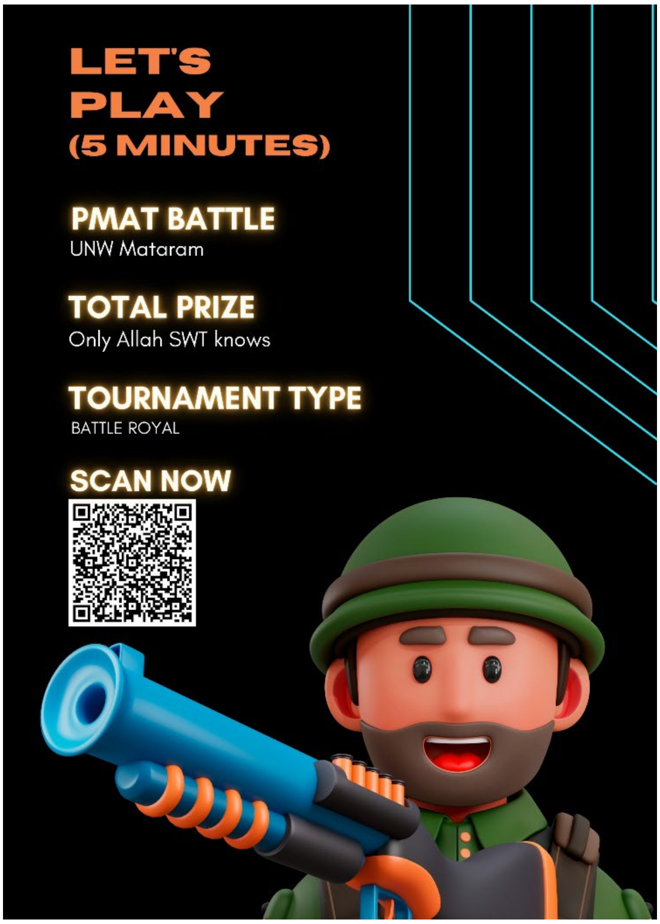
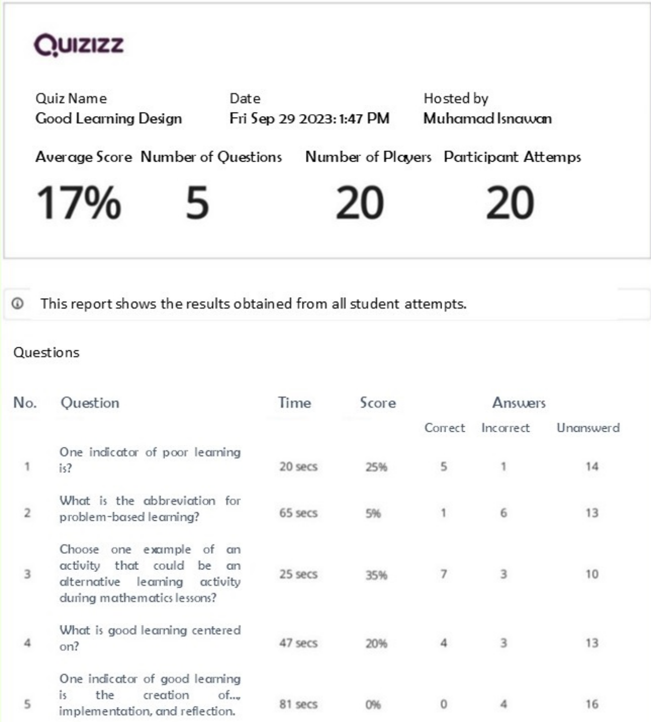


Figure 5. Footage of game-playing activities in a blended didactic design based on STEM


Quizizz

Quiz Name	Date	Hosted by
Good Learning Design	Fri Sep 29 2023: 1:47 PM	Muhamad Isnawan

Average Score	Number of Questions	Number of Players	Participant Attemps
17%	5	20	20

This report shows the results obtained from all student attempts.

Questions

No.	Question	Time	Score	Answers Correct	Incorrect	Unanswerd
1	One indicator of poor learning is?	20 secs	25%	5	1	14
2	What is the abbreviation for problem-based learning?	65 secs	5%	1	6	13
3	Choose one example of an activity that could be an alternative learning activity during mathematics lessons?	25 secs	35%	7	3	10
4	What is good learning centered on?	47 secs	20%	4	3	13
5	One indicator of good learning is the creation of..., implementation, and reflection.	81 secs	0%	0	4	16

Figure 6. Recapitulation of student answers to the *Let's Play* activity

Figure 7. Example of documentation of student activities in the *Let's Search* activity

A few minutes after watching, some students responded to the video by answering questions. WS (student 2) emphasized that the main message of the video is that every small act of kindness has a big impact on oneself and others. MH (student 3) salso highlighted something similar: that small actions have a big impact on the future. Even though the students' responses were in line with the objectives of *Let's Watch*, there was a shortage in time allocation due to the large number of questions, which took time for students to give long answers. The next activity, *Let's Play*, involved students scanning a QR code and using the *Quizizz* game code from a model lecturer. Students were actively involved in the game without any problems, even though the model lecturer did not provide follow-up to their answers. The main goal of this activity was to ensure students' understanding of the prerequisites, which are represented in **Figure 6**.

After completing *Quizizz*, students were challenged to find a solution to a problem within 30 minutes. They read the problem, then scanned a QR code containing two math learning videos. With tools like cardboard, markers, rulers, and scissors, they represented solutions. After watching the video, students discussed how to determine the type of learning that is better and identify its characteristics. Then they began to record their answers. Student activities in this activity were recorded in the documentation depicted in **Figure 7**. Students worked together to create a representation, posting their answers in class with additional pictures and quotes, as seen in **Figure 8**.

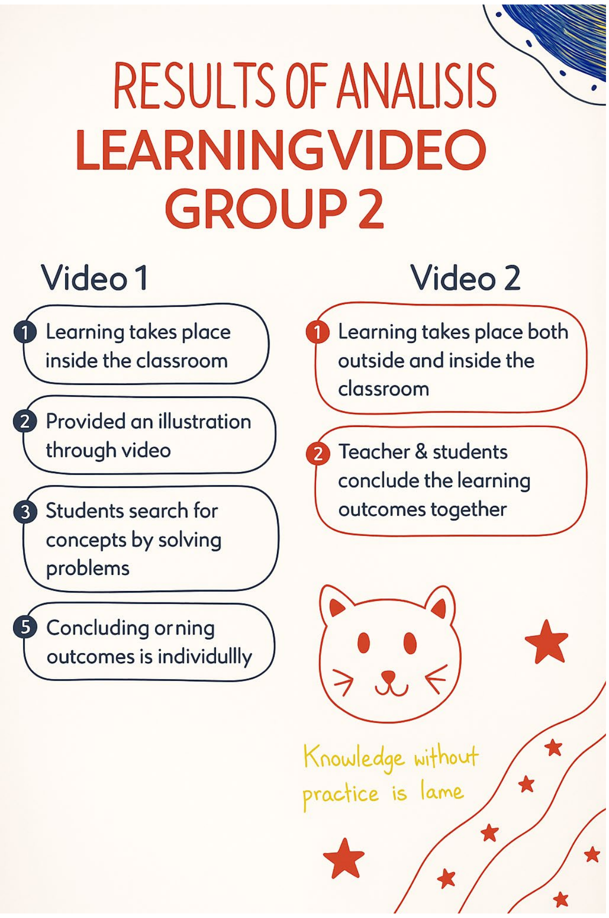


Figure 8. Excerpts of students' answers to the *Let's Search* activity

The next step, *Let's Tell Stories*, involved a verbal presentation from the BK (student 1) representing the first group. BK (student 1) appeared fluent and clear in explaining his group's answers. The group concluded that the second video was better. Meanwhile, SN (student 4) and SF (student 5) from other groups also performed well, concluding that the videos were more interesting because of active learning outside the classroom. In contrast, SM (student 6), who represented another group, chose the first video because of the variety of methods, use of media, interaction between teachers and students, and application of games in learning. They assessed the characteristics of good learning, including the use of games in learning. During *Let's Tell Stories*, there were no significant obstacles, but some groups were unable to share the process and answers due to time constraints. A coping strategy was to allow groups that had not yet spoken to contribute to the next *Let's Conclude* session. A student from another group concluded that effective mathematics learning involves hands-on practice, games, and small group learning. However, a student from the last group tried to create a learning pattern instead of mentioning the appropriate characteristics. Other students' reactions highlighted the incompatibility of these answers with the characteristics of effective learning. Finally, the model lecturer confirmed the characteristics of effective mathematics learning. The *Let's Practice* activity had to end due to a lack of time and was replaced by *My Reflection*. RH (student 7) summarized the learning, highlighting student-teacher interaction and the use of games as characteristics of good mathematics learning. All students enjoyed the blended design. The model lecturer ended with prayers and greetings.

RQ4: What are the conditions of students' representation abilities during the implementation of the STEM-based blended lecture design?

During the implementation of a STEM-based blended lecture design, student representation performance was evaluated. As a result, visual ability reached 100%, and around 80% of students were able to represent contextually. The comparison is depicted in **Figure 9**. **Figure 9** shows that there is an increase in the percentage or number of students who are able to create visual representations by 60%. In relation to physical representation, there is an increase of around 60% in the number of students, 20% for symbolic representation, 40% for verbal representation, and 60% for contextual representation. In other words, there is an increase in the variety of forms of representation used by students after the implementation of the STEM-based blended lecture design.

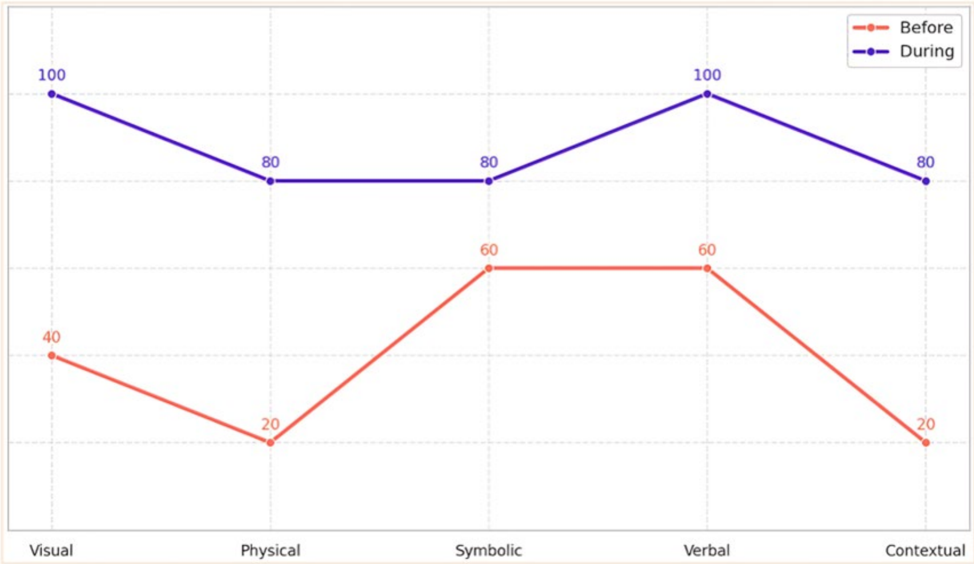


Figure 9. Comparison of student representation abilities

RQ5: What is the form of the redesign of the STEM-based blended lecture design after its implementation?

After the lesson, the researcher and several lecturers held a reflection session to provide input on the previous STEM-based blended lecture design. *Let's Watch* activities took a lot of time because of the excessive number of questions. The first suggestion was to reduce the number of questions. The lack of feedback from *Let's Play* was another obstacle. The second suggestion was to respond to student answers. *Let's Practice* was not implemented, and researchers did not provide improvements because of the time used in *Let's Watch*. The assumption was that improving *Let's Watch* could divert time to *Let's Practice*. The purpose of the evaluation was to provide constructive input on course design.

Discussion

The results of the study reveal that students at the beginning of the lecture experience obstacles in the form of low mathematical representation skills. This is because students are not given the opportunity to explore or convey their ideas in various forms. Therefore, this study designs a STEM-based blended learning lecture to facilitate students in conveying their ideas or concepts. The results of the study then reveal that the lecture design optimizes the representation skills of prospective mathematics teachers, both in visual, symbolic, physical, verbal, and contextual forms. These results align with prior studies by Azmidar and Husan (2022) and Ratumanan et al. (2022), highlighting the insufficient development of students' representation skills during lectures. Man et al. (2022) and Raza et al. (2020) have noted that there aren't enough opportunities to use ideas and solve problems, which contributes to this trend. Enhancing opportunities for problem-solving and idea expression during lectures is crucial to fostering optimal development in students' representation abilities.

Upon reviewing **Figure 2**, it is evident that modes of representation, specifically physical and contextual, register relatively low levels. This contrasts with Saifiyah and Retnawati (2019) research, revealing challenges in students employing visual and symbolic modes due to insufficient practice in problem-solving. In lectures, limited opportunities for problem-solving and idea exploration hinder skill development. This study proposes STEM-based blended lecture designs as an alternative, enabling students to access and solve problems using their ideas. Previous research by Man et al. (2022) and Zweekhorst and Essink (2019) supports the effectiveness of problems or case studies in aiding students in constructing concepts related to the characteristics of effective learning.

Incorporating ICT, the STEM-based blended lecture design utilizes QR codes, inspirational videos, and online test applications to enhance learning. QR codes, known for easy information conveyance and streamlined lecture design (Ahmed and Zaneldin, 2020; Wei et al., 2023), link to various data types, including learning videos and game-based online tests (Dan et al., 2024; Othman et al., 2023; Vuksanović et al., 2021). ICT or learning videos engage students, fostering interest and motivation, while game-based tests are employed to heighten students' enthusiasm for learning (Baig and Yadegaridehkordi, 2023; Hainey et al., 2020; Hamad et al., 2024; Harper et al., 2024; Ibrahim et al., 2024; Love, 2023; Mendoza-Diaz et al., 2020; Thornton and Lammi, 2021).

The design comprises three integral learning activities: initial, core, and final. Based on the idea that there are three main stages of learning: preparation, lecture, and evaluation (Aylward, 2012), the first activities help students understand the learning goals, get motivated through motivational videos, and see how much they already know using *Quizizz*. Clear learning objectives, as BSKAP (2022), guide students towards targeted achievements. The core activities, structured based on the theory of didactical situation, encompass action situations, formulation, and validation (Brousseau, 2002; Yenil et al., 2023). Commencing with problem or case studies, students are tasked with solution completion, encouraging idea exploration and expression using cardboard for visual and symbolic representation optimization (Cooper and Alibali, 2012; Raza et al., 2020). To enhance verbal, contextual, and physical representation abilities, students articulate their processes verbally, providing real-world analogies (Huinker, 2015). This multifaceted approach aims to cultivate comprehensive representation skills through interactive and engaging blended learning activities.

The final activity in STEM-based blended lecture design is an institutionalization situation (Suryadi, 2019b), which consists of student activities using the concept of good learning characteristics in constructing a grid for mathematics learning in the classroom. It is hoped that this activity will be able to strengthen students' representation skills using the concepts they have learned. The last activity is *My Reflection*. This activity facilitates students in carrying out self-assessments (Yang and Xin, 2022) to check whether the learning objectives targeted at the start of the lecture have been achieved or not. Apart from that, in this activity, students also check their feelings during learning. This activity aims to ensure that learning does not make students bored or sad. This is considered important to do so that students' mental health is maintained. Moreover, mental health has become one of the focuses of global research in the world of education in Indonesia (Kotera et al., 2022; Welan and Zulkifli, 2023).

Furthermore, when implementing the STEM-based blended lecture design, no significant obstacles were found. In other words, most of the student responses are in line with the researchers' expectations. The results of this research are then in line with several previous studies (Fitriati et al., 2023; Haryoto and Narimo, 2013; Sukarma et al., 2024), which reveal that learning designs planned through lesson study activities and didactical design research tend to get positive responses from students. This is because the blended lecture design based on STEM is prepared jointly with other lecturers so that various possible student responses can be anticipated (Huang and Shimizu, 2016; Marfuah et al., 2022).

There was something quite interesting during the implementation of the STEM-based blended lecture design, namely the students' ability to convey ideas verbally. In general, all students are able to communicate ideas using verbal representations and provide examples of analogies in actual mathematics learning. This is because in the STEM-based blended lecture design, students are given the opportunity to express opinions, both about inspirational videos and about solutions to problems being solved. The results of this research are in line with several previous studies (Haryoto and Narimo, 2013; Raza et al., 2020), which reveal that learning that provides students with the opportunity to express opinions when solving problems or conducting case studies tends to be able to optimize students' competencies, especially the ability to communicate verbally.

Apart from that, when implementing STEM-based blended lecture designs, students tend to be able to represent ideas visually and symbolically. This is because students are given supporting facilities, such as smartphones, cardboard, and colored markers, as tools to explore or convey ideas. The results of this research are in line with Arefaine et al. (2022), which reveal that students' representation abilities tend to develop optimally when students are provided with tools to represent ideas, especially the use of ICT (Badmus et al., 2024). Students successfully recognize key features of effective mathematics learning, including multi-directional interactions, engaging physical activities, the integration of learning videos, ice-breaking strategies, and opportunities for game-based learning. Notably, the study identifies student-centered learning as a pivotal characteristic. These findings align with established theories by Anthony and Walshaw (2009) and Zweekhorst and Essink (2019), emphasizing that student-centered approaches and hands-on activities are fundamental principles of effective mathematics education.

As described in previous research results, information has been obtained that one of the obstacles during implementation is that there are activities that cannot be carried out due to time constraints. The activity is *Let's Practice*. This is because learning activities devote too much time to the initial lecture activity, namely *Let's Watch*. In fact, initial learning activities should not take up more than 25% of the allocated learning time. The results of this research are in line with several previous studies (Khalafov, 2021; Mathematical Sciences HE Curriculum Innovation Project, 2012), which reveal that the allocation of learning time for student-centered learning tends to be more than for ordinary learning. Following up on these shortcomings, researchers redesigned the blended lecture design. The redesign includes limiting the number of questions in the *Let's Watch* activity. This is intended so that there is not too much time allocated for these activities, and the existing time allocation can be used to work on *Let's Practice* activities. This redesign is based on a theory that reveals that reflection is an important part that is integrated with learning activities (BSKAP, 2022; Yang and Xin, 2022).

A pivotal finding in this research is the ongoing increase in student representation abilities across all modes. The blended lecture design is STEM-based, allowing freedom of expression, leveraging smartphone usage, and posing stimulating questions, facilitating this improvement. These results align with prior studies (Peled and Schocken, 2014; Yosiana et al., 2021), emphasizing the beneficial role of smartphones in lectures. Moreover, the research corresponds with (Rosnawati et al., 2022), highlighting that trigger questions enhance students' engagement and participation in learning mathematics. The comprehensive alignment underscores the efficacy of blended lecture designs in fostering enhanced student representation abilities. In addition, STEM-based mathematics learning is also highly recommended in schools. This is intended so that students' mathematical competence can develop optimally by training students to integrate various disciplines in life, such as science, technology, and engineering. In fact, STEM-based learning seems to attract students' interest and motivation to learn because it produces work or products that make students feel like scientists or engineers.

CONCLUSION

Before implementing the STEM-based design, prospective mathematics teachers are indicated to have low representation skills. It is proven that the percentage of students' visual, physical, and contextual representation abilities does not reach 50%. In fact, representational ability is one of the standard processes for learning mathematics. To find out the factors that cause students' representation abilities to not develop optimally, researchers conduct a prospective analysis. The results of the analysis reveal that students' representation abilities do not develop optimally because they are given fewer opportunities to explore ideas and use these ideas in solving problems or cases. Apart from that, lectures conducted by lecturers tend not to utilize STEM to help students solve problems or cases.

Responding to these causal factors, researchers prepared a problem-based blended lecture design that provides students with the opportunity to explore, use, and display ideas in various forms of representation with the help of posters and STEM media. Some of the STEM integrated into the design are QR codes, inspirational YouTube videos, and *Quizizz*. Blended lecture design based on STEM consists of several activities, namely *Let's Listen, Let's Watch, Let's Play, Let's Search, Let's Tell Stories, Let's Conclude, Let's Practice,* and *My Reflection*. This activity is referred to as an epistemic lecture pattern. During implementation, no significant obstacles were found, except regarding time allocation. Time allocation tends to be less for *Let's Practice* activities because quite a lot of time allocation is used in previous activities. However, after analysis, blended lecture design was able to optimize students' representation abilities. It has been proven that around 80% of students have been able to present ideas physically, symbolically, and contextually, and 100% of students have been able to present ideas visually and verbally.

The research faces limitations, most notably the absence of live observers during the implementation of blended lectures. Observations rely on video recordings. Another limitation is the lack of feedback from the lecturer model on *Let's Play* activities, which are designed to assess students' prerequisite knowledge during lectures. Future research involves all observers during the implementation of STEM-based blended lecture designs. Additionally, researchers offer feedback on student answers in *Quizizz* for more comprehensive insights. Another limitation is the time allocation, which does not include *Let's Practice* activities. The researcher recommends that future researchers study solutions to address these problems, such as using AI to solve them.

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REFERENCES

Ahmed, W. and Zaneldin, E. (2020). Blending QR code with video learning in the pedagogical process for the college foundation level. *Interactive Technology and Smart Education*, 17(1), 67–85. https://doi.org/10.1108/ITSE-08-2019-0043

Altunışık, S., Uzun, S. and İnel Ekici, D. (2023). The effect of problem-based STEM practices on pre-service science teachers conceptual understanding. *Journal of Pedagogical Research*, 7(5), 344–358. https://doi.org/10.33902/jpr.202323628

Anthony, G. and Walshaw, M. (2009). Characteristics of effective teaching of mathematics: A view from the west. *Journal of Mathematics Education*, 2(2), 147–164.

Arefaine, N., Michael, K. and Assefa, S. (2022). GeoGebra assisted multiple representations for enhancing students' representation translation abilities in calculus. *Asian Journal of Education and Training*, 8(4), 121–130. https://doi.org/10.20448/edu.v8i4.4309

Aylward, R. (2012). The three phases of learning. *International Proceedings of Economics Development and Research*, 63(15), 32–36. https://doi.org/10.7763/IPEDR

Azmidar and Husan, H. (2022). Enhancing students' mathematical representation ability through mathematics learning. *Hipotenusa: Journal of Research Mathematics Education*, 5(2), 90–104. https://doi.org/10.36269/hjrme.v5i2.969

Badmus, O. T., Jita, T. and Jita, L. C. (2024). Exploring undergraduates' underachievement in science technology engineering and mathematics: Opportunity and access for sustainability. *European Journal of STEM Education*, 9(1), 10. https://doi.org/10.20897/ejsteme/14741

Baig, M. I. and Yadegaridehkordi, E. (2023). Flipped classroom in higher education: A systematic literature review and research challenges. *International Journal of Educational Technology in Higher Education*, 20, 61. https://doi.org/10.1186/s41239-023-00430-5

Brousseau, G. (2002). *Theory of Didactical Situations in Mathematics*. Kluwer Academic Publishers.

BSKAP. (2022). *Panduan pembelajaran dan asesmen: Pendidikan anak usia dini, pendidikan dasar, dan menengah*, BSKAP. Available at: https://kurikulum.kemdikbud.go.id/wp-content/uploads/2022/06/Panduan-Pembelajarn-dan-Asesmen.pdf.

Büchele, S. and Feudel, F. (2023). Changes in students' mathematical competencies at the beginning of higher education within the last decade at a German university. *International Journal of Science and Mathematics Education*, 21(8), 2325–2347. https://doi.org/10.1007/s10763-022-10350-x

Cooper, J. L. and Alibali, M. W. (2012). Visual representations in mathematics problem-solving: Effects of diagrams and illustrations, in Proceeding of the 34th Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education (pp. 281–288). https://files.eric.ed.gov/fulltext/ED584910.pdf

Creswell, J. W. and Creswell, J. D. (2018). *Research Design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publication, Inc.

Dan, N. N., Trung, L. T. B. T., Nga, N. T. and Dung, T. M. (2024). Digital game-based learning in mathematics education at primary school level: A systematic literature review. *Eurasia Journal of Mathematics, Science and Technology Education*, 20(4), em2423. https://doi.org/10.29333/ejmste/14377

Deeken, C., Neumann, I. and Heinze, A. (2020). Mathematical prerequisites for STEM programs: What do university instructors expect from new STEM undergraduates? *International Journal of Research in Undergraduate Mathematics Education*, 6(1), 23–41. https://doi.org/10.1007/s40753-019-00098-1

Fitriati, F., Rosli, R. and Iksan, Z. H. (2023). Enhancing prospective mathematics teachers' lesson planning skills through lesson study within school university partnership program. *Journal on Mathematics Education*, 14(1), 69–84. https://doi.org/10.22342/JME.V14I1.PP69-84

Goldin, G. A. (2020). Mathematical representations, in S. Lerman (ed), *Encyclopedia of Mathematics Education* (pp. 566–572). Springer International Publishing. https://doi.org/10.1007/978-3-030-15789-0_103

Hainey, T., Baxter, G. and Ford, A. (2020). An evaluation of the introduction of games-based construction learning in upper primary education using a developed game codification scheme for scratch. *Journal of Applied Research in Higher Education*, 12(3), 377–402. https://doi.org/10.1108/JARHE-02-2018-0031

Hamad, F., Shehata, A. and Al Hosni, N. (2024). Predictors of blended learning adoption in higher education institutions in Oman: Theory of planned behavior. *International Journal of Educational Technology in Higher Education*, 21(1), 13. https://doi.org/10.1186/s41239-024-00443-8

Harper, C. V., McCormick, L. M. and Marron, L. (2024). Face-to-face vs. blended learning in higher education: A quantitative analysis of biological science student outcomes. *International Journal of Educational Technology in Higher Education*, 21, 2. https://doi.org/10.1186/s41239-023-00435-0

Haryoto, S. and Narimo, S. (2013). Contextual math learning based on lesson study can increase study communication. *International Journal of Education*, 5(4), 48. https://doi.org/10.5296/ije.v5i4.4440

Huang, R. and Shimizu, Y. (2016). Improving teaching, developing teachers and teacher educators, and linking theory and practice through lesson study in mathematics: An international perspective. *ZDM Mathematics Education*, 48, 393–409. https://doi.org/10.1007/s11858-016-0795-7

Huinker, D. (2015). Representational Competence: A renewed focus for classroom practice in mathematics. *Wisconsin Teacher of Mathematics*, 67(2), 4–8.
Ibrahim, M., Herwin, H., Retnawati, H., Firdaus, F. M., Umar, U. and Mufidah, M. (2024). STEM learning for students mathematical numeracy ability. *European Journal of STEM Education*, 9(1), 20. https://doi.org/10.20897/ejsteme/15750
Isnawan, M. and Alsulami, N. M. (2024). Didactical design for online learning in ordering fractions. *International Journal of Didactic Mathematics in Distance Education*, 1(1), 1–12. https://doi.org/10.33830/ijdmde.v1i1.7653
Khairunnisak, C., Johar, R., Zubainur, C. M. and Sasalia, P. (2021). Learning trajectory of algebraic expression: Supporting students' mathematical representation ability. *Mathematics Teaching Research Journal*, 13(4), 27–41.
Khalafov, A. (2021). Factors obstructing the application of student-centered education at schools in Azerbaijan. *International Journal of Education and Learning*, 3(3), 183–190. https://doi.org/10.31763/ijele.v3i3.101
Kotera, Y., Kotera, H., Taylor, E., Wilkes, J., Colman, R. and Riswani, R. (2022). Mental health of Indonesian university students: U.K. comparison and relationship between mental health shame and self-compassion. *Stigma and Health*, 9(3), 239–248. https://doi.org/10.1037/sah0000420
Love, T. S. (2023). Embedding safety in integrative STEM teaching methods courses for pre-service elementary educators. *Journal of Technology Education*, 34(2), 22–42. https://doi.org/10.21061/jte.v34i2.a.2
Lusiana, L. and Ningsih, Y. L. (2018). Students' mathematical representation ability through implementation of Maple. *Infinity Journal*, 7(2), 155. https://doi.org/10.22460/infinity.v7i2.p155-164
Mainali, B. (2021). Representation in teaching and learning mathematics. *International Journal of Education in Mathematics, Science and Technology*, 9(1), 1–21. https://doi.org/10.46328/ijemst.1111
Man, Y. L., Asikin, M. and Sugiman. (2022). Systematic literature review: Students' mathematical representation ability in mathematics learning. *Daya Matematis: Jurnal Inovasi Pendidikan Matematika*, 10(1), 36–44.
Marfuah, M., Suryadi, D., Turmudi, T. and Isnawan, M. G. (2022). Providing online learning situations for in-service mathematics teachers' external transposition knowledge during COVID-19 pandemic: Case of Indonesia. *Electronic Journal of E-Learning*, 20(1), 69–84. https://doi.org/10.34190/ejel.20.1.2388
Mathematical Sciences HE Curriculum Innovation Project. (2012). Student-centred approaches in mathematics, Mathcentre. Available at: https://www.mathcentre.ac.uk/resources/uploaded/Studentcentered.pdf.
Mendoza-Diaz, N., Mai, B., Martinez, J., Jabarkhail, S. and Garcia, D. (2020). Face-to-face and online classes in a technology management program: A comparative study. *Journal of Technology Education*, 32(1), 21–34. https://doi.org/10.21061/jte.v32i1.a.2
Miles, M. B., Huberman, A. M. and Saldana, J. (2014). *Qualitative Data Analysis: A methods sourcebook* (3rd ed.). SAGE Publications, Inc.
Ningtyas, D. Y., Fuad, Y. and Lukito, A. (2019). Kemampuan representasi mahasiswa pendidikan matematika dalam menyelesaikan soal kalkulus. *Kreano, Jurnal Matematika Kreatif-Inovatif*, 10(1), 27–36. https://doi.org/10.15294/kreano.v10i1.17334
Nursyahidah, F., Albab, I. U. and Mulyaningrum, E. R. (2023). Learning design of quadrilateral STEM-based through lesson study. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(11), em2352. https://doi.org/10.29333/ejmste/13747
Othman, N. A. F., Jaini, A., Ismail, M., Zainoddin, A. I., Radzi, S. F. M. and Sundram, V. P. K. (2023). Gamification in online learning: A case study among university students in Malaysia. *Asian Journal of University Education*, 19(2), 282–293. https://doi.org/10.24191/ajue.v19i2.22239
Peled, S. and Schocken, S. (2014). Mobile learning and early age mathematics, in *Proceedings of the 10th International Conference Mobile Learning* (pp. 19–25).
Putra, F. G., Lengkana, D., Sutiarso, S., Nurhanurawati, N., Saregar, A., Diani, R., Widyawati, S., Suparman, S., Imama, K. and Umam, R. (2023). Mathematical representation: A bibliometric mapping of the research literature (2013–2022). *Infinity Journal*, 13(1), 1–26. https://doi.org/10.22460/infinity.v13i1.p1-26
Rabu, S. N. A., Hussin, H. and Bervell, B. (2019). QR code utilization in a large classroom: Higher education students' initial perceptions. *Education and Information Technologies*, 24(1), 359–384. https://doi.org/10.1007/s10639-018-9779-2
Ratumanan, T. G., Ayal, C. S. and Tupamahu, P. Z. (2022). Mathematical representation ability of mathematics education study program students. *Jupitek: Jurnal Pendidikan Matematika*, 5(1), 50–59. https://doi.org/10.30598/jupitekvol5iss1pp50-59
Raza, S. A., Qazi, W. and Umer, B. (2020). Examining the impact of case-based learning on student engagement, learning motivation and learning performance among university students. *Journal of Applied Research in Higher Education*, 12(3), 517–533. https://doi.org/10.1108/JARHE-05-2019-0105
Rosnawati, R., Tuharto and Hamdi, S. (2022). Trigger questions in mathematics learning simulation in micro teaching course: An overview of asking question types. *AIP Conference Proceedings*, 2575(1), 050024. https://doi.org/10.1063/5.0108877

Saifiyah, S. and Retnawati, H. (2019). Why is mathematical representation difficult for students? *Journal of Physics: Conference Series*, 1397, 012097. https://doi.org/10.1088/1742-6596/1397/1/012093

Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A. K., Yang, X. and Kaiser, G. (2021). Mathematics teacher learning to notice: A systematic review of studies of video-based programs. *ZDM Mathematics Education*, 53, 119–134. https://doi.org/10.1007/s11858-020-01216-z

Sari, D. P. and Rosjanuardi, R. (2018). Errors of students learning with react strategy in solving the problems of mathematical representation ability. *Journal on Mathematics Education*, 9(1), 121–128. https://doi.org/10.22342/jme.9.1.4378.121-128

Setiawan, Y. E. (2022). Prospective teachers representations in problem solving of special angle trigonometry functions based on the level of ability. *Infinity Journal*, 11(1), 55–76. https://doi.org/10.22460/infinity.v11i1.p55-76

Sudirman, Rodríguez-Nieto, C. A., Dhlamini, Z. B., Chauhan, A. S., Baltaeva, U., Abubakar, A., Dejarlo, J. O. and Andriani, M. (2023). Ways of thinking 3D geometry: Exploratory case study in junior high school student. *Polyhedron International Journal in Mathematics Education*, 1(1), 15–34. https://doi.org/10.59965/pijme.v1i1.5

Sukarma, I. K., Isnawan, M. G. and Alsulami, N. M. (2024). Research on nonroutine problems: A hybrid didactical design for overcoming student learning obstacles. *Human Behavior and Emerging Technologies*, 2024. https://doi.org/10.1155/2024/5552365

Supriadi, A. and Ningsih, Y. L. (2022). Kemampuan representasi matematis mahasiswa pada materi distribusi peluang. *Indikta: Jurnal Inovasi Pendidikan Matematika*, 4(2), 14–25. https://doi.org/10.31851/indiktika.v4i1.7678

Suryadi, D. (2019a). *Landasan Filosofis Penelitian Desain Didaktis (DDR)*. Pusat Pengembangan DDR Indonesia.

Suryadi, D. (2019b). *Penelitian Desain Didaktis (DDR) dan Implementasinya*. Gapura Press.

Takaria, J., Wahyudin, Sabandar, J. and Dahlan, J. A. (2020). Relationship between statistical literacy and mathematical representation of students through collaborative problem solving model. *Infinity Journal*, 9(2), 183–196. https://doi.org/10.22460/infinity.v9i2.p183-196

Tashtoush, M. A., Al-Qasimi, A. B., Shirawia, N. A. and Rasheed, N. M. (2024). The impact of STEM approach to developing mathematical thinking for calculus students among Sohar University. *European Journal of STEM Education*, 9(1), 13. https://doi.org/10.20897/ejsteme/15205

Thobela, N. M., Sekao, R. D. and Ogbonnaya, U. I. (2023). Mathematics teachers' use of textbooks for instructional decision-making in lesson study. *Journal of Pedagogical Research*, 7(4), 1–13. https://doi.org/10.33902/JPR.202320138

Thornton, T. and Lammi, M. (2021). An exploration of augmented reality in an introductory engineering graphics course. *Journal of Technology Education*, 32(2), 38–55. https://doi.org/10.21061/JTE.V32I2.A.3

Vuksanović, N., Demirović Bajrami, D., Petrović, M. D. and Grigorieva, E. M. (2021). QR codes as a tool for receiving feedback about guests' satisfaction at destinations. *Journal of Place Management and Development*, 14(1), 19–31. https://doi.org/10.1108/JPMD-03-2020-0025

Wei, J. J., Lin, H. H. and Chen, S. L. (2023). Design of teaching aids in STEAM education and fuzzy hierarchical analysis of their educational effect. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(11), em2354. https://doi.org/10.29333/ejmste/13749

Welan, Z. A. H. A. and Zulkifli, A. F. (2023). The impact of online learning on mental illness among physical and health education students at Malaysian public university. *Asian Journal of University Education*, 19(4), 632–637. https://doi.org/10.24191/ajue.v19i4.24625

Yang, L. P. and Xin, T. (2022). Changing educational assessments in the post-COVID-19 Era: From assessment of learning (AoL) to assessment as learning (AaL). *Educational Measurement: Issues and Practice*, 41(1), 54–60. https://doi.org/10.1111/emip.12492

Yenil, T., Arslan, Ç. and Tapan Broutin, M. S. (2023). Triangle inequality concept teaching: The theory of didactic situations case. *Journal of Pedagogical Research*, 7(4), 14–29. https://doi.org/10.33902/JPR.202318961

Yosiana, Y., Djuandi, D. and Hasanah, A. (2021). Mobile learning and its effectiveness in mathematics. *Journal of Physics: Conference Series*, 1806, 012081. https://doi.org/10.1088/1742-6596/1806/1/012081

Zainudin, Z. A. and Zulkiply, N. (2023). Gamification in learning: Students' motivation and cognitive engagement in learning business using Quizizz. *Asian Journal of University Education*, 19(4), 823–833. https://doi.org/10.24191/ajue.v19i4.24928

Zweekhorst, M. and Essink, D. (2019). Integrating community service learning into a master's program. *Journal of Applied Research in Higher Education*, 11(2), 235–249. https://doi.org/10.1108/JARHE-04-2017-0054