p-ISSN: 2086-2334
e-ISSN: 2442-4218

Kreano

Jurnal Matematika Kreatif-Inovatif

This journal publishes the research articles
on mathematics education.

Vol. 14, No. 2
2023, December
Page 216-412

Published by Mathematics Department (UNNES)
in collaboration with AMLI
(AHU-0012896.AH.01.07.Tahun 2017)

Kreano, Jurnal Matematika Kreatif-Inovatif has been accredited based on the Ministerial Decree of RISTEKBRIN Number 148/M/KPT/2020, dated August 3rd, 2020. Based on this decree, Kreano has raised to grade SINTA 2 starting from Vol. 10(2), 2019 to Vol. 15(1), 2024.

Kreano, Jurnal Matematika Kreatif-Inovatif publishes research article on mathematics education, has indexed on IPI, ISJD, Garuda, Google Scholar, DOAJ, BASE, SHERPA/RoMEO, ResearchGATE, and ACI (Asean Citation Index). All articles will get PREFIX DOI by CrossREF and able to find on Mendeley.

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Cover Story: Research and development on mathematics learning media become interesting again.

Kreano

Jurnal Matematika Kreatif-Inovatif

Volume 14(2), 2023
December

Visit the page:
https://journal.unnes.ac.id/nju/index.php/kreano/issue/view/1698

DOI Address:
https://doi.org/10.15294/kreano.v14i2

Topic of the volume:
The research on development of mathematics teaching media become interesting again.

ISSN by PDII-LIPI,
p-ISSN. No. 2086-2334 (Print)
e-ISSN. No. 2442-4218 (Online)

Published by
Mathematics Department of UNNES
(UNNES JOURNAL as Online Publisher)
In collaboration with AMLI
2023

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Jurnal Matematika Kreatif-Inovatif

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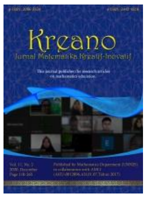

Preface

Assalamu 'alaikum wr.wb.

Dear readers of the Jurnal Kreano,

Kreano, Jurnal Matematika Kreatif-Inovatif, Vol. 14 (2), December 2023 is here to greet loyal readers, academics who have a young spirit in serving, storing, criticizing, and providing solutions to every phenomenon that occurs in learning mathematics through steps the scientific.

It seems that regarding educational evaluation, in the future there could be more than 1 tier. To really understand whether students have understood the material, questions in the form of 1 tier have recently started to evolve into more 2 to 4 tier questions. The development of this form of evaluation is quite good, and Kreano presents research results on 2 tier and 4 tier type questions.

The variety of types of research that continues to develop, and quality makes editors increasingly think about whether it is better to develop forms of research that can be published in Kreano. Currently, we are still playing on a small scope, empirical educational research. However, this does not rule out the possibility that systematic literature reviews and/or meta analyzes could start to be published on Kreano. Hopefully the Journal together with authors, researchers, and readers can be part of the process of improving the quality of education.

Happy reading!

Wassalamu 'alaikum wr.wb.

Semarang, December, 1st 2023
Chief of Editor

Isnarto, Dr.

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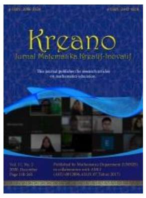

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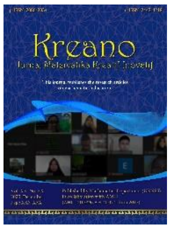

Misconceptions of Quitters Students in Solving Algebra Problems Using a Two-Tier Multiple Choice Diagnostic

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Abstract

Understanding students' misconceptions about algebra material is essential to determine corrective steps, so students avoid making continuous errors in learning algebra. This study used a qualitative approach to identify students' misconceptions about solving algebraic problems, especially quitters. The subjects in this study were class VII students of SMP Argopuro Panti who were included in the quitters' type. The instruments used were an adversity quotient questionnaire, a two-tier multiple-choice diagnostic test instrument, and an interview guide. The results of this study are in the form of misconceptions by quitters students, namely: 1) in working on subtraction questions in algebraic forms, students only subtract the first term; 2) students experience misconceptions in operating numbers; 3) students experience misconceptions about patterns for algebraic exponents; and 4) students make conceptual errors in using the cross out system. To overcome this, teachers can provide accurate explanations, use appropriate learning models, and recall student prerequisite material before learning new material. By identifying students' misconceptions in solving algebraic problems, the teacher can correct and improve students' inaccurate understanding.

Keywords: Misconceptions; Quitters Students; Algebra; Two-Tier Multiple Choice Diagnostic.

Information of Article

Subject classification	*97D70 Learning difficulties and student errors (aspects of mathematics education)*
Submitted	*14 June 2023*
Review Start	*15 June 2023*
Initial Review Finish	*19 June 2023*
Round 1 Finish	*3 July 2023*
Round 2 Finish	*13 July 2023*
Round 3 Finish	*15 July 2023*
Accepted	*15 July 2023*
Published	*28 July 2023*
Similarity Check	*5%*

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Abstrak

Memahami miskonsepsi siswa pada materi aljabar penting dilakukan agar dapat menentukan langkah perbaikan sehingga siswa tidak melakukan kesalahan yang berkelanjutan dalam pembelajaran aljabar. Penelitian ini menggunakan pendekatan kualitatif yang bertujuan untuk mengidentifikasi miskonsepsi siswa, khususnya siswa quitters, dalam menyelesaikan soal aljabar. Subjek dalam penelitian ini yaitu siswa kelas VII SMP Argopuro Panti yang termasuk dalam tipe quitters. Instrumen yang digunakan adalah angket adversity quotient, instrumen tes two-tier multiple choice diagnostic, dan pedoman wawancara. Hasil dari penelitian ini berupa miskonsepsi yang dilakukan siswa quitters, yaitu: 1) dalam mengerjakan soal pengurangan bentuk aljabar, siswa hanya mengurangi suku pertamanya saja; 2) siswa mengalami miskonsepsi dalam mengoperasikan bilangan; 3) siswa mengalami miskonsepsi mengenai pola untuk perpangkatan aljabar; dan 4) siswa melakukan kesalahan konsep dalam menggunakan sistem coret. Untuk mengatasinya guru dapat memberikan penjelasan yang akurat, penggunaan model pembelajaran yang tepat, serta mengingat kembali materi prasyarat siswa sebelum mempelajari materi baru. Dengan mengidentifikasi miskonsepsi siswa dalam mengerjakan soal aljabar, guru dapat melakukan upaya untuk mengoreksi dan memperbaiki pemahaman siswa yang kurang tepat.

INTRODUCTION

Mathematics plays a significant role and function in human life, both in the social, spiritual, health, and economic fields, as well as in advancing science and technology. Almost every activity carried out by humans cannot be separated from mathematics in it. The importance of mathematics makes Sunita Yadav, in the article he wrote to say that "without mathematics, there can be neither science nor engineering" (Yadav, 2019).

In its development, the branch of mathematics is independent and does not depend on other disciplines. Mathematics is an essential tool in applying and developing other fields of science or in the development of mathematics itself. Therefore, mathematics is the queen of science in education. This follows what Kaushik Das wrote: "Mathematics as a science-based course or discipline is known as a queen of all subjects" (Das, 2019).

Understanding mathematics well is very important to study various disciplines so that mathematics is taught at almost all levels of education (Kulsum et al., 2019). In addition, mathematics has the function of expanding the ability to convey ideas using language through various mathematical models, such as sentences and mathematical equations, diagrams, graphs, or tables. (Rahmah, 2018). Mathematics learning aims to help students deal with various mathematics-related problems in everyday life. Realizing the importance of the role of mathematics, students are expected to be able to understand mathematics well.

However, according to the 2018 PISA report, the mathematical abilities of Indonesian students scored 379 and ranked 73rd (OCED, 2019). This score describes Indonesian students' level of understanding and mastery of mathematics, which is classified as very low. This condition is concerning because many countries have better mathematical abilities than Indonesia. Therefore, it is necessary to take action to improve the quality of mathematics education in Indonesia.

One field in mathematics that is important for students to understand and is closely related to everyday life is algebra. Marpa explained, "Algebra is a branch of mathematics, which turns relations examined by using symbols and numbers to generalized equations" (Marpa, 2019). Algebra can also be interpreted as a field of mathematics that uses mathematical statements to describe the relationship between various objects.

"Algebra is considered by many to be the mathematical gatekeeper, and mastering algebra skills gives students a passport to educational opportunities and an expansive job market" (Bone et al., 2021; Ralston et al., 2018). The sentence states that algebra is a necessary foundation or fundamental in mathematics. Therefore, understanding and mastering algebra is a crucial initial stage in studying further mathematics. Students with a good understanding of algebra can study more complex mathematical topics, solve problems, and develop the logical thinking abilities needed in various academic and professional contexts.

However, in reality, not all students easily understand algebra material. Several Argopuro Panti Middle School students needed help understanding basic concepts, resulting in repeatedly making the same errors. For example, students needed help understanding the basic rules regarding algebraic subtraction operations. So that in solving equations, there were students who made errors such as removing brackets in deductions without multiplying each term in it by a negative sign. Errors experienced by these students, if not handled properly, can result in students experiencing difficulties in learning more complex algebraic concepts. Errors made by these students can be caused by several things, such as a lack of understanding of concepts, confusion in applying formulas, and lack of practice.

Internal and external factors of students can also affect the learning difficulties or obstacles experienced by students. Internal factors refer to factors that come from within the student, while external factors refer to factors that come from outside the student. "Internal factors consist of physical, psychological, and health factors. External factors consist of family, school, and community" (Tokan & Imakulata, 2019).

To face difficulties in working on algebraic math problems, an adversity quotient is needed to overcome them. "Adversity quotient measures people's ability to withstand setbacks, get rid of adversity, and surpass difficulties" (Qin et al., 2019). A high adversity quotient increases the possibility of individuals having an optimistic and innovative attitude when facing problems (Hidayat et al., 2018). Conversely, if the adversity quotient of someone is low, it is assumed they tend to give up easily, avoid challenges, and experience high-stress levels. (Huda & Damar, 2021).

In the adversity quotient, three types are given: climbers, campers, and quitters (Pradika et al., 2019). The climbers' type describes individuals who dare to face challenges in solving problems or matters and are ready to take the necessary risks. The campers type refers to individuals who desire to face challenges but remain consistent in not taking or accepting risks. Meanwhile, the quitters' type refers to individuals who lack the motivation to face challenges, tend to avoid them, quickly feel hopeless, and often give up. (Gaffar et al., 2021).

Therefore, the role of the teacher is needed to help students, especially quitters, understand mathematics in algebraic material. The role of a teacher is focused on more than teaching activities alone. However, it is also responsible as a full manager in implementing the teaching and learning process in the classroom (Buchari, 2018). One method that teachers can do is to analyze students' misconceptions of algebra material. Students are said to need clarification when students have an accurate understanding. Al-Mutawah et al. also explained, "When students systematically use incorrect rules or the correct rule in an inappropriate domain, there are likely to be misconceptions" (Al-Mutawah et al., 2019).

Analyzing students' misconceptions has significant benefits in an educational context. Teachers can find out students' misconceptions so that the teacher can design appropriate learning strategies and models. Involving students actively in the learning process that focuses on correct understanding and analyzing students' misconceptions can also improve their learning outcomes.

Several researchers have discussed the analysis of students' misconceptions in learning mathematics, as in research conducted by Mahfuzhoh, who discussed the analysis of junior high school students' misconceptions about integer material. (Mahfuzhoh, 2019). In addition, Jitu Halomoan Lumbantoruan and Hendrikus Male also conducted research on the analysis of students' misconceptions in the mathematics education study program on probability theory on essay problems. (Lumbantoruan & Male, 2020). After considering the previous description, the researcher believes that recognizing students' misconceptions is crucial to increase their learning success.

This study takes the subject of algebra as the research subject—namely, quitters-type students. A two-tier multiple-choice diagnostic evaluation technique will be used to identify the misconceptions made by quitters in solving algebraic problems. Thus, the researcher took the research title "Misconceptions of Quitters Students in Solving Algebraic Problems Using a Two-Tier Multiple Choice Diagnostic."

METHOD

This research was conducted at SMP Argopuro Panti, which is located at Lapangan Street No. 39, Panti, Panti District, Jember Regency, East Java. The school research was collected over two days, from 22 May 2023 to 23 May 2023, from 07:00 to 08.10 WIB. This study applied a qualitative approach. Qualitative research was chosen because this research will explain the misconceptions of quitters students in solving algebraic problems using a two-tier multiple-choice diagnostic.

The research procedure was to identify the problem first, then formulate the objectives. This research aims to find and identify the misconceptions made by quitters in solving algebraic problems.

Next is to determine the research subjects used. The subjects in this study were class VII students of SMP Argopuro Panti who were included in the quitters' category. Based on the results of the adversity quotient questionnaire, it was found that 5 class VII students of SMP Argopuro Panti were included in the quitters' category and were the subjects of this study.

Then the research subjects were given a two-tier multiple-choice diagnostic test on algebra material. From the results of these tests, students who had misconceptions were interviewed about why they had them. Data in the form of two-tier multiple-choice diagnostic test results, interviews, and observations that have been carried out are processed and analyzed; conclusions are drawn (see Figure 1).

The instrument in this research is the researcher as the main instrument. In addition to the main instrument, three supporting instruments were used: an adversity quotient **questionnaire** to determine the research subject, a two-tier multiple-choice diagnostic **test** on algebraic material, and **an interview guide**. The methods used in the data collection process were tests, interviews, and observations. In contrast, in the data analysis process, three stages are carried out: data condensation, data presentation, and drawing conclusions.

To validate the data, the researcher did the triangulation method. Researchers collected data using various methods, namely diagnostic tests, interviews, and field observations. This is done to get a variety of points of view and complement one another.

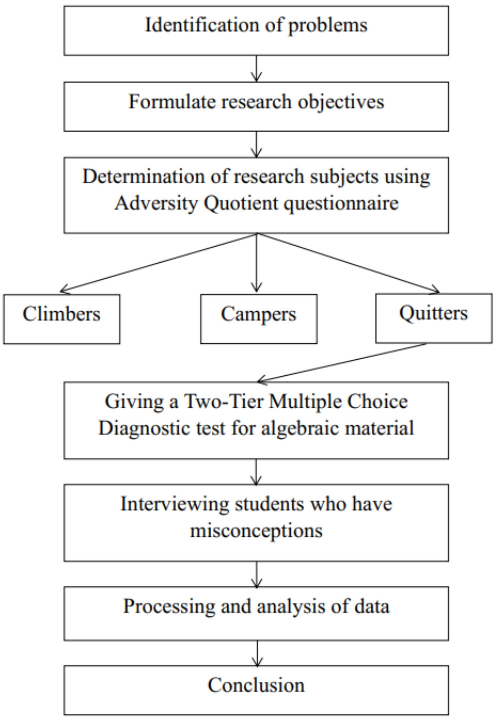


Figure 1. A flow chart regarding research procedures

RESULTS AND DISCUSSION

Results

This research used a two-tier multiple-choice diagnostic instrument to identify quitters' misconceptions in solving algebraic problems. This diagnostic test consists of 5 questions covering five concepts: addition, subtraction, multiplication, exponents, and division in algebra. The test results grouped students' answers into three categories: understanding concepts, misconceptions, and not understanding concepts.

Students are included in the understanding category if the student can choose the correct answer at the first level and the right reason at the second level. Students are included in the misconceptions category if the student can choose the correct answer at the first level but chooses the wrong reason at the second level or students who choose the wrong answer at the first level. However, the student can choose the right reason at the second level. In comparison, students are included in the not understanding category if students choose the wrong answer at the first level and the wrong reason at the second level (Syaifuddin et al., 2022).

The test results of quitters-type students working on algebraic questions using the two-tier multiple-choice diagnostic test instrument are presented in the following table.

Table 1. Student test results using a two-tier multiple-choice diagnostic

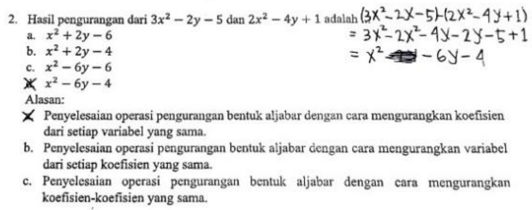
Student	Question Number		
	A (T-T)	B (T-F/F-T)	C (F-F)
UH	3, 4	5	1, 2
LFNJ		3	1, 2, 4, 5
DHA	1, 3	2, 5	4
DKA	3, 4	5	1, 2
AZM	1, 3	2, 4	5

A: Understanding; B: Misconception; C: Not understanding

From Table 1, one student's answer was taken for each number of questions that experienced misconceptions for further analysis.

Misconceptions about Number 2

In question number 2, students were given problems regarding algebraic subtraction operations. Two students needed clarification in working on this problem, namely DHA and AZM. For example, in the results of DHA work, he chose the wrong answer at the first level, but the reason chosen was correct at the second level.



2. Hasil pengurangan dari $3x^2 - 2y - 5$ dan $2x^2 - 4y + 1$ adalah $(3x^2 - 2x - 5) - (2x^2 - 4y + 1)$
a. $x^2 + 2y - 6$ $= 3x^2 - 2x^2 - 4y - 2y - 5 + 1$
b. $x^2 + 2y - 4$ $= x^2 - 6y - 4$
c. $x^2 - 6y - 6$
d. $x^2 - 6y - 4$
Alasan:
a. Penyelesaian operasi pengurangan bentuk aljabar dengan cara mengurangkan koefisien dari setiap variabel yang sama.
b. Penyelesaian operasi pengurangan bentuk aljabar dengan cara mengurangkan variabel dari setiap koefisien yang sama.
c. Penyelesaian operasi pengurangan bentuk aljabar dengan cara mengurangkan koefisien-koefisien yang sama.

Figure 2. Students misconceptions in solving problem number 2.

The following is an excerpt of the researcher interview (P) with DHA.

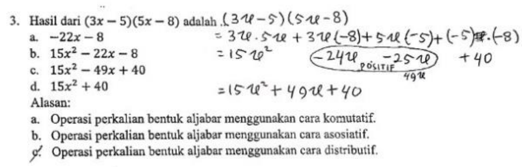
P : *What was your first step when solving question number 2?*
DHA : *I immediately cut it down, Miss. The instruction was ordered to subtract.*
P : *In subtracting, how do you do it?*
DHA : *By marking the min between the two, Ms. So* $3x^2 - 2y - 5 - 2x^2 - 4y + 1$*. After that, it is collected with those that have the same variables. Then do it, sis.*
P : *Are you sure about your answer?*
DHA : *Sure, as far as I remember, miss.*

The student can give good reasons that the step to solve the subtraction of algebraic forms is to subtract the coefficients of each same variable that is the same or terms that are similar. However, when working on these questions, students made errors when solving $-(2x^2 - 4x + 1)$. The student did not multiply each term by a negative sign; he only multiplied the negative sign on the first term.

Based on interviews with these students, it is known that in solving the subtraction of $3x^2 - 2y - 5$ and $2x^2 - 4y + 1$, the student only added a subtraction (negative) sign in between, so the student answers is $3x^2 - 2y - 5 - 2x^2 - 4y + 1$ as a solution step. This causes the results to be inaccurate because they need to follow the concepts accepted by experts. The errors made by these students were due to students needing an adequate understanding of the basic concepts of algebraic subtraction resulting in misconceptions in these students.

Misconceptions about Number 3

In question number 3, students were given problems regarding multiplication operations in algebraic forms. There was one student who had a misconception, namely LFNJ, in solving this problem. LFNJ chose the wrong answer at the first level, but the correct reason was chosen at the second level.



3. Hasil dari $(3x - 5)(5x - 8)$ adalah $(3x - 5)(5x - 8)$
a. $-22x - 8$ $= 3x.5x + 3x(-8) + 5x(-5) + (-5).(-8)$
b. $15x^2 - 22x - 8$ $= 15x^2 - 24x - 25x + 40$ (positif, $49x$)
c. $15x^2 - 49x + 40$
d. $15x^2 + 40$ $= 15x^2 + 49x + 40$
Alasan:
a. Operasi perkalian bentuk aljabar menggunakan cara komutatif.
b. Operasi perkalian bentuk aljabar menggunakan cara asosiatif.
c. Operasi perkalian bentuk aljabar menggunakan cara distributif.

Figure 3. Students misconceptions in solving problem number 3

The following is an excerpt of the researcher interview (P) with LFNJ.

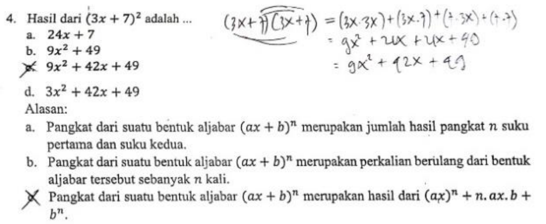
P : *What was your first step when solving question number 3?*
LFNJ : *I multiplied it using the distributive property, Miss.*
P : *In solving these questions, were there any confusion or obstacles?*
LFNJ : *I did not find my answer in your answer choices. When I did* $-24x - 25x$*, I got the result of* $49x$*, not* $-49x$*.*
P : *Are you sure if* $-24x - 25 = 49x$*?*
LFNJ : *I am sure the teacher once explained that if downbeat meets negative, the result is positive.*

The student can give good reasons that the step to solve the multiplication of algebraic forms is to use the distributive method. In operating the multiplication of the algebraic form of the two terms with the two terms, the student used the distributive property correctly, namely by following the pattern $(ax + b)(cx + d) = ax.cx + ax.d + b.cx + b.d$. but the error made was when operating $-24x - 25x$ this student answered $49x$, instead of $-49x$.

Based on interviews with these students, given that they understand when operating $-a - b$ always resulted in positive answers, as was done in operating multiplication $(-a) \times (-b)$. However, operating $-a-b$ and $(-a) \times (-b)$ is different. This caused the final answers obtained by these students to be inaccurate because they were not by the concepts accepted by experts. The errors made by students in solving question number 3 were due to students' understanding and prerequisite skills for the material of arithmetic operations in algebraic forms that were not quite right.

Misconceptions about Number 4

In question number 4, students were given problems regarding the operation of exponential algebraic forms. In solving this problem, one student had a misconception, namely AZM. AZM chose the correct answer at the first level, but the reasons were chosen wrong at the second level.


4. Hasil dari $(3x+7)^2$ adalah ...
a. $24x+7$
b. $9x^2+49$
c. $9x^2+42x+49$
d. $3x^2+42x+49$

Alasan:
a. Pangkat dari suatu bentuk aljabar $(ax+b)^n$ merupakan jumlah hasil pangkat n suku pertama dan suku kedua.
b. Pangkat dari suatu bentuk aljabar $(ax+b)^n$ merupakan perkalian berulang dari bentuk aljabar tersebut sebanyak n kali.
c. Pangkat dari suatu bentuk aljabar $(ax+b)^n$ merupakan hasil dari $(ax)^n + n.ax.b + b^n$.

Figure 4. Students misconceptions in solving problem number 4

The following is an excerpt of the researcher interview (P) with AZM.

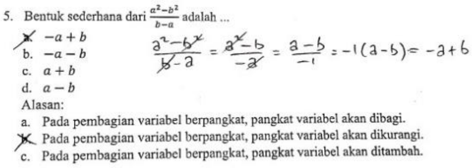
P : What was your first step when solving question number 4?
AZM : I multiplied $3x+7$ with $3x+7$.
P : Why did you choose that reason at the second level?
AZM : When I multiplied $3x+7$ with $3x+7$, I got the answer of $(3x)^2 + 2.3x.7 + 7^2$, so I chose c reason.
P : Are you sure if these reasons are valid? If the power is not 2, does it still follow that pattern?
AZM : I have yet to try. However, it is the same if the power is not two because I tried for power two earlier.

The student can give the correct answer in solving algebraic, exponential operations. When solving $(3x+7)^2$, the student multiplied $(3x+7)$ with itself repeatedly according to the number of powers. The student uses the distributive property correctly in describing it, namely by following a pattern $(ax+b)(ax+b) = (ax)^2 + 2.ax.b + b^2$. However, when choosing a reason, the student's error was the power of an algebraic form $(ax+b)^n$ resulted $(ax)^n + n.ax.b + b^n$. This pattern is applied to squares or powers of 2 only. If $n \neq 2$, the pattern will change and cannot be used.

Based on interviews with these students, given that in solving questions, when he had proven $(ax+b)^2 = (ax)^2 + 2.ax.b + b^2$, students concluded that the pattern also applied to all n. Students rush to conclude without trying if n is a number other than two first. Even though the pattern for algebraic exponents varies according to the power. The error in choosing the reason the student made was not following the concept accepted by the experts. This error occurs because students need an adequate understanding of the basic concepts of algebraic exponents, especially regarding patterns and formulas in them, resulting in misconceptions in these students.

Misconceptions about Number 5

In question number 5, students were given problems regarding dividing algebraic forms. Three students needed clarification in solving this problem: UH, DHA, and DKA. For example, in the results of DKA's answer, he chose the wrong answer at the first level, but the reason that was chosen was correct at the second level.


5. Bentuk sederhana dari $\frac{a^2-b^2}{b-a}$ adalah ...

a. $-a+b$

b. $-a-b$

c. $a+b$

d. $a-b$

Alasan:

a. Pada pembagian variabel berpangkat, pangkat variabel akan dibagi.

b. Pada pembagian variabel berpangkat, pangkat variabel akan dikurangi.

c. Pada pembagian variabel berpangkat, pangkat variabel akan ditambah.

Figure 5. Students' misconceptions in solving problem number 5

The following is an excerpt of the researcher interview (P) with DKA.

P : What was your first step when solving question number 5?

DKA : There are variables a and b in the numerator and denominator, so I crossed out the same ones.

Q : Are you sure about what you are doing? Why?

DKA : Insya Allah, miss. I once noted the discussion of the problem in my book; for example, $\frac{a \times b^2}{a \times b}$, the same numerator and denominator can be crossed out immediately so that the result is b only. I did it the same as that Miss. I followed the example there.

The student can give good reasons that the step to complete the division of power variables is to subtract the power of the same variable. However, students made errors when solving the questions above by directly dividing or crossing out the same variables without factoring them first. In solving these questions, before carrying out the cross-out system, it must be factored first to get the same value so that it can be crossed out or eliminated. That is because the cross-out system involves multiplication with fractions.

Based on interviews with these students, given that they understand when operating $\frac{a^2-b^2}{b-a}$ can be immediately crossed out as can be done in multiplication, for example, in processing $\frac{a \times b^2}{a \times b} = b$. However, operating $\frac{a^2-b^2}{b-a}$ and $\frac{a \times b^2}{a \times b}$ is a different thing in the process. This caused the final answer obtained by these students to be inaccurate because they were not following the concepts accepted by experts. The errors made by students in solving question number 5 were due to students' lack of adequate understanding of the basic concept of algebraic division, especially in the cross-out system, resulting in misconceptions among these students.

Discussion

This research was conducted at SMP Argopuro Panti for two days, from 22 May 2023 to 23 May 2023, from 07:00 to 08:10 WIB. This discussion focused on quitters students at SMP Argopuro Panti who experienced misconceptions when solving two-tier multiple-choice diagnostic test questions on algebra material. Two-tier multiple-choice diagnostic questions still need to be discovered by the public and even teachers as educators. This test has a function to assess and analyze students understanding of concepts. "Two-tier multiple choice test can be used as an insight into making a form of assessment that challenges students' knowledge, providing a technique to assess students' concepts, especially in classroom learning" (Rintayati et al., 2020). Some examples of questions used in the study can be seen in the figure below.

1. Hasil penjumlahan dari $6x + 4y + 3$ dan $-3x - 2y - 4$ adalah ...
   a. $9x + 6y + 7$
   b. $9x + 2y - 1$
   c. $3x + 6y + 7$
   d. $3x + 2y - 1$

   Alasan:
   a. Dalam operasi penjumlahan bentuk aljabar, hanya yang memiliki koefisien yang sama dapat dijumlahkan.
   b. Dalam operasi penjumlahan bentuk aljabar, hanya suku-suku sejenis saja yang dapat dijumlahkan.
   c. Dalam operasi penjumlahan bentuk aljabar, semua suku-sukunya dapat dijumlahkan dan tidak perlu memperhatikan jenisnya.

2. Hasil pengurangan dari $3x^2 - 2y - 5$ dan $2x^2 - 4y + 1$ adalah ...
   a. $x^2 + 2y - 6$
   b. $x^2 + 2y - 4$
   c. $x^2 - 6y - 6$
   d. $x^2 - 6y - 4$

   Alasan:
   a. Penyelesaian operasi pengurangan bentuk aljabar dengan cara mengurangkan koefisien dari setiap variabel yang sama.
   b. Penyelesaian operasi pengurangan bentuk aljabar dengan cara mengurangkan variabel dari setiap koefisien yang sama.
   c. Penyelesaian operasi pengurangan bentuk aljabar dengan cara mengurangkan koefisien-koefisien yang sama.

Figure 6. Example of two-tier multiple-choice diagnostic questions used in the study.

Two-tier multiple choice diagnostic questions consist of 2 levels. The first level follows the traditional multiple-choice format commonly used to measure student knowledge. Meanwhile, at the second level, the model is like the first level, but the aim is to train students' reasoning abilities. At this second level, multiple choices ask for reasons for students' answers at the first level (Syaifuddin et al., 2022). This is in line with what was said by Andriyanto et al., "The first level (tier I) in the TTMC is a matter of material concepts, while the second level (tier II) is the reason for the answers for level I" (Andriyatno et al., 2023).

. The two-tier diagnostic test differs from the one-tier diagnostic test in the number of questions levels asked and the depth in identifying student misconceptions regarding the material. The two-tier diagnostic test has the advantage of providing more detailed information about students' misconceptions through additional answer choices in the second level. However, two-tier diagnostic tests also have weaknesses. This two-tier test cannot accurately distinguish students who have a correct understanding of the concept, who need help understanding the concept, or who have misconceptions. These tests can provide more detailed information, but interpretation of the results still requires careful consideration.

This study aims to identify the misconceptions of quitters students in solving algebraic problems. “Misconception is students’ understanding of a concept that cannot be accepted scientifically” (Anam, 2018). Misconceptions can occur when students try to construct a new understanding based on incorrect or inaccurate previous understanding. "Misconceptions can occur when students are trying to construct knowledge by translating or understanding new experiences in the form of preconception" (Duda et al., 2020).

The results of identifying student misconceptions can assist teachers in designing corrective actions in learning algebra as an effort to overcome misconceptions held by quitters. Teachers can help students improve their understanding of algebraic material by making exemplary efforts. As a result, student learning outcomes in algebra material can increase.

Based on the results of tests using two-tier multiple-choice diagnostic algebra material, interviews, and class observations conducted, several things needed to be corrected by students. In problem number 2 regarding subtraction of algebraic forms, students operated $(3x^2 - 2y - 5) - (2x^2 - 4y + 1)$ only by subtracting the first term, such that it became $3x^2 - 2y - 5 - 2x^2 - 4y + 1$. This misunderstanding aligns with the research results from (Angelo A. Legarde, 2022), which shows one of the results of student answer that multiplies the monomial factor by the first term only.

In question number 3 regarding the multiplication of algebraic forms, students correctly solved using the distributive property. However, students need clarification in operating $-24x - 25x$; the student answered $49x$ instead $-49x$. This is because students understanding and prerequisite skills for algebraic arithmetic operation material must be corrected. This misunderstanding aligns with the research results (Sari & Afriansyah, 2020), which stated that students needed help understanding arithmetic operations, so they could not complete the addition and subtraction of algebraic forms.

In question number 4 regarding algebraic exponents, students needed clarification about the pattern for algebraic exponents. Students assume that there is an algebraic form $(ax + b)^n$ will always follow the pattern $(ax)^n + n.ax.b + b^n$. This pattern only applies to $n = 2$. If $n \neq 2$, then the pattern will change and not be the same (Ma'rufi & Pasandaran, 2019).

In question number 5 regarding the division of algebraic forms, students needed to understand the cross-out system. Students made errors by directly dividing or crossing out the same variables without factoring them first. This misunderstanding aligns with the research results from (Rahayu et al., 2021), which state that students make understanding errors in simplifying fractional forms in algebra.

Based on the results of the identification of misconceptions carried out on quitters students above, there are several things that teachers as educators can do to be able to overcome these misconceptions, including 1) provide an accurate explanation of the concepts being studied; 2) using learning model that is adapted to the needs of students in order to make it easier for students to understand the concepts being taught correctly, and 3) recall to strengthen students abilities and prerequisite material before learning new material.

Implications

This research identifies misconceptions that occur in students, especially quitters-type students, when learning algebra. By knowing these misconceptions, teachers can specifically develop plans and efforts to overcome them. This research contributes to developing more effective learning strategies to deal with students' misconceptions. With a deep understanding of the misconceptions experienced by these students, teachers can design activities and learning methods that aim to help students improve their understanding.

This research provides valuable insights to teachers regarding misunderstandings or misconceptions that often occur in students so that it can be used as a guide in lesson planning, providing appropriate feedback, and developing more effective learning methods to deal with these misconceptions. In addition, this research could influence the development of better algebra learning materials. Material developers can design more appropriate content by understanding students' misconceptions, including case examples, illustrations, and questions to overcome common misunderstandings or misconceptions.

Limitations

This research is limited to algebraic arithmetic operations, such as addition, subtraction, multiplication, exponential, and algebraic division. Therefore, the results of this study are only limited to misconceptions related to this topic. Other misconceptions not included in this study related to other algebraic concepts may exist.

With a small number of research subjects, the representation of variations in students may need to be appropriately covered. Differences in levels of understanding, socio-economic background, level of intelligence, and other factors that influence misconceptions may need to be adequately reflected in limited subjects. As a result, the generalization of research results is limited to that subject and cannot be applied in general. The results of this study also cannot be immediately generalized to quitters students in other schools or different contexts.

CONCLUSION

This study revealed the misconceptions among quitters students at SMP Argopuro Panti when solving algebraic problems using a two-tier multiple-choice diagnostic test instrument. Based on the results of the study, several misconceptions were found by students, namely: 1) in solving algebraic subtraction questions, students only subtract the first term; 2) students experience misconceptions when operating algebraic forms $-24x - 25x$ answered $49x$; 3) students experience misconceptions about the algebraic, exponential pattern, namely for all n always follow the pattern $(ax+b)^n = (ax)^n + n.ax.b + b^n$; and 4) in operating the division of algebraic forms, students make misunderstanding in using the cross out system. From the description above, this study found the most common misconception among students: students often need to correctly apply the correct rules in solving algebraic arithmetic operations. Efforts that the teacher can make to overcome these misconceptions include providing accurate explanations of the concepts being studied, using learning models adapted to students' needs, and recalling strengthening students' abilities and prerequisite material before learning new material.

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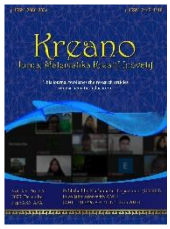
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 228-242



Android-Based Media in Course of Mathematics Learning Strategy at Universitas Muhammadiyah Sumatera Utara

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Abstract

This research is presented through teaching materials used by lecturers in learning procedures that have not aroused student learning interest, so students experience difficulties understanding the material provided in distance learning (online). This study's goal is to design android-based mathematics learning media in mathematics learning strategies courses. This android-based mathematics learning media design model utilizes Research and Development (R&D) developed by Borg and Gall. The product trial population in this study was students at Universitas Muhammadiyah Sumatera Utara majoring in mathematics education using a questionnaire as an instrument. This trial went through three stages, namely individual group trials, small group trials, and field trials. Before the product test is carried out, an expert validation test is carried out on the content and design of mathematics learning media using a questionnaire according to predetermined indicators, then after that, a questionnaire analysis is carried out to see the percentage and comparison validation of mathematics learning media. This study designed an android-based mathematics learning media that was declared valid and suitable for use by 3 material experts who received a mean score of 3,73 (valid) and 2 programming experts with an average score of 3,87 (valid). So, it can be concluded that android-based mathematics learning media is valid and feasible to be used as a mathematics learning media. The results of this study can be applied in the process of distance learning (online) and face-to-face to further enhance student enthusiasm for learning.

Keywords: Android, Mathematics Learning Media, Mathematics Learning Strategies.

Information of Article	
Subject classification	*97C70 Teaching-learning processes in mathematics education*
Submitted	*15 October 2022*
Review Start	*17 October 2022*
Round 1 Finish	*29 October 2022*
Round 2 Finish	*23 March 2023*
Round 3 Finish	*30 May 2023*
Accepted	*20 June 2023*
Published	*28 July 2023*
Similarity Check	*22%*

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Abstrak

Penelitian ini disajikan melalui bahan ajar yang digunakan dosen dalam prosedur pembelajaran yang belum membangkitkan minat belajar mahasiswa, sehingga mahasiswa mengalami kesulitan dalam memahami materi yang diberikan dalam pembelajaran jarak jauh (online). Penelitian ini bertujuan merancang media pembelajaran matematika berbasis android pada mata kuliah strategi pembelajaran matematika. Model perancangan media pembelajaran matematika berbasis android ini memanfaatkan Research and Development (R&D) yang dikembangkan oleh Borg and Gall. Populasi uji coba produk dalam penelitian ini adalah mahasiswa Universitas Muhammadiyah Sumatera Utara jurusan pendidikan matematika dengan menggunakan kuesioner sebagai instrumennya. Uji coba ini melalui tiga tahapan, yaitu uji coba kelompok individu, uji coba kelompok kecil, serta uji coba lapangan. Sebelum dilakukan uji coba produk, dilakukan uji validasi ahli terhadap isi dan desain media pembelajaran matematika menggunakan angket sesuai indikator yang telah ditentukan, kemudian setelah itu dilakukan analisis angka untuk melihat proporsi dan perbandingan validasi media pembelajaran matematika. Penelitian ini merancang media pembelajaran matematika berbasis android yang telah dinyatakan valid dan layak digunakan oleh 3 orang ahli materi yang memperoleh skor rata-rata 3,73 (valid) dan 2 orang ahli pemprograman dengan skor rata-rata 3,87 (valid). Sehingga dapat disimpulkan bahwa media pembelajaran matematika berbasis android valid dan layak digunakan sebagai media pembelajaran matematika. Hasil penelitian ini dapat diterapkan dalam proses pembelajaran jarak jauh (online) dan tatap muka untuk lebih meningkatkan semangat belajar mahasiswa.

INTRODUCTION

Education is a way to influence, protect, and provide assistance aimed at student maturity or in other words help students to be quite capable of carrying out their life tasks without the help of others (Suriansyah, 2011) Maturity in the sense of education is not maturity in the everyday sense identified with aspects of age. A student can be said to be mature in the sense of education if the student has and shows the following characteristics: (1) the existence of stability and stability of behavior; (2) an attitude of responsibility; and (3) the existence of an independent nature (Suriansyah, 2011).

Education is a learning plan to develop students' potential. Potentials developed include diverse abilities, self-control, personality, intelligence, noble character, and life skills. These life skills are needed in the life of society, nation, and state. Education basically forms knowledge, knowledge is expanded access through technological advances.(Chang et al., 2021)

The development of the world of education requires lecturers to be able to compete in improving education in Indonesia. Improving education begins with the provision of learning media in the learning process in the classroom. Government Regulation Number 32 of 2013 concerning National Education Standards states that educators must have academic qualifications and competencies as learning agents, be physically and mentally healthy, and have the ability to realize national education goals (Peraturan Pemerintah, 2013).

What is meant by educators as learning *agents* is the role of educators, among others, as facilitators, motivators, boosters, and inspirational learning for students. The 2013 Ministerial Regulation on national standards of higher education states that the learning process must be interactive, fun, and challenging, and motivate students to participate actively, as well as provide opportunities for creativity and independence. (Peraturan Pemerintah, 2013)

The world of education, in the current era, has been facilitated by advances in science and technology. One of them is an android or mobile phone. The development of the Android operating system, ranging from gadgets, desk PCs, smartphones, and other applications that have other Android operating systems can certainly support students to own and use android in everyday life and during learning. (Muyaroah & Fajartia, 2017)

The world of education has entered the era of the media world, where the learning process prioritizes media, rather than lecture methods, so the role of learning media is increasingly important to realize an effective learning process because the function of media in learning can generate new desires and interests, increase motivation and stimulation of learning activities and even affect psychological students (Saputri, 2016)

In our society, lecturers are given professional status. As professionals, they are expected to use best practices to help students learn important skills and attitudes. It is no longer enough for lecturers to be warm and compassionate towards students, nor is it enough for them to use teaching practices based solely on intuition, personal preference, or conventional wisdom (Arends, 1959).

So, students will not be able to fulfill their needs with traditional education. Students need interactive learning media as a technology product. This is due to students' interest in learning that needs to be improved. The reality in traditional education is the transfer of information without the learning process. As a result, students lose interest in learning and their learning outcomes are not good. (Lee & Osman, 2012).

One that can help smooth the learning process is learning media. So, lecturers must use media as much as possible or even make the media. Therefore, as much as possible lecturers must be able to make teaching material media that are by the material to be taught to students. The purpose of suitability is for students to receive learning well and correctly as a whole. Where learning media is a tool to make facts, concepts, principles, and procedures seem more real or concrete (Yuni, 2017).

The material presented is easy to understand. This is consistent with student research (Gluzman et al., 2018). Media selection must consider learning goals to be achieved, accuracy, student availability, hardware availability, technical quality, and cost, among others (Wahab et al., 2021).

Learning media as a learning process is communication and takes place in a system such that communication cannot occur without media and learning as a communication process cannot function optimally. AECT (*Association for Education and Communication Technology* (1977) in Yuniastuti; Miftakhuddin; Khoiron, 2021), defines media as any form and channel used to conveys a message or information. When a medium conveys a message or information for teaching or instructional purposes, the medium is known as an instructional medium.

Learning Media is everything used in learning activities to channel or convey messages from a source in a planned manner, to create an effective thing. Learning media always consists of two important elements, namely equipment or hardware elements and message elements that it carries (software). Things that include device media, namely: materials, equipment, hardware, and software. Material terms are closely related to terminal equipment and hardware terms are related to software terms. Material is something that can be used to store a message to be conveyed to an audience by using certain tools or the shape of the object itself, such as transparencies for overhead devices, films, film strips, slide films, images, graphics, and printed materials. Meanwhile, equipment is something that is used to move or convey something stored by the material to the audience. (Pito, 2018)

Learning media as a learning process is communication and takes place in a system, so without media, communication will not occur and the learning process as a communication process will not be able to take place optimally. Thus, it can be concluded that learning media is an intermediary used to convey information or lessons to stimulate students to learn.

From the point of view of mathematics learning, the media is more likely to be called mathematical teaching aids which are interpreted as tools to facilitate the explanation of mathematical concepts. With the use of teaching aids, mathematics learning strategies are very helpful to provide optimal understanding for student communicants. As in explaining mathematics learning strategies, lecturers as communicators can use visual props to clarify mathematics learning strategies, so that student communicants can understand and remember explanations conveyed through visual props.

The mathematics learning media that will be developed in the mathematics learning strategy course is presented as simply as possible, to help the difficulties experienced by students during learning. By implementing and developing android-based learning media, which can facilitate students in the learning process. Learning media is a supporting tool used by teachers in learning (Amil et al., 2020).

Android is a Linux-based operating system for mobile phones, such as smartphones and tablet computers. As an open application, Android is an open platform for developers to create applications that can be used by various smartphones. (Komputer, 2013)

The mathematics learning strategy course aims to provide provisions for prospective mathematics teacher students to have the knowledge, experience, abilities, and skills to choose and implement efficient and effective mathematics learning strategies. Learning strategy is the next step of the learning design process, namely, how to get to the learning process in question is a series of external events for students designed to improve the internal process of learning.

Mathematics learning is a strategy or tips that are deliberately planned by the teacher, regarding all learning preparations so that the implementation of learning runs smoothly and the goals in the form of learning outcomes can be achieved optimally. Learning strategies need to show the integrated use of mathematics on various problems, to try to make students understand that in real life often problems or symptoms contain various aspects so that branches of mathematics can be used together to analyze the problem or phenomenon. So, it can be said that mathematics learning strategies are activities in mathematics learning that must be carried out by teachers and students so that learning objectives can be achieved effectively and efficiently (Rahman, 2018).

Mathematics education students are prospective educators or prospective mathematics teachers who play an active role in improving students' mathematical abilities in the future. Therefore, the role of mathematics education lecturers is very necessary to improve the mathematical ability of prospective student teachers. The Committee on Undergraduate Programs in Mathematics (CUPM) (Schumacher & Siegel, 2015) recommends that each mathematics course should be an activity that will assist students in developing analytical, critical reasoning, problem-solving, and communication skills. Therefore, mathematics learning provided in universities must be able to hone students so that they have basic competencies in mathematics, namely understanding, problem-solving, reasoning, mathematical connections, communication, critical thinking, and creative thinking.

From the description above, the need for android-based mathematics learning media during a pandemic or for distance learning in mathematics learning strategy courses, it is hoped that students will be interested in these courses and the learning process will be interactive, fun, challenging, and motivate students to actively participate, as well as provide opportunities for creativity and independence, even if learning is carried out online or remotely.

This mathematics learning strategy learning media is designed because there are no android-based mathematics learning strategy learning media. After the learning media design is completed, the learning media is validated by material experts and media experts. Based on the results of validation that have been carried out by a team of material experts and media experts, it is stated that android-based learning media has a very interesting category to be presented to students to be used as learning media in mathematics learning strategy courses.

Some research relevant to the research conducted by researchers includes: The purpose of this study is to develop an e-module based on Realistic Mathematics Education (RME) on a System of Two Variable Linear Equations. Based on the calculation results, the e-module is feasible for material experts and media experts. From the validation of material and media experts, the same category was obtained which was very good with an average score of 3,56 and 3,65. Based on tests for students, e-modules are practical with criteria for small and large class trials with scores of 3,17, and 3,22. Based on the average combination of expert material and media and trials, students achieved an average score of 3,40 with excellent criteria. In conclusion, a smartphone-based e-module with a Realistic Mathematics Education approach to the material of a two-variable linear equation system is feasible to use. (Fahmi et al., 2022)

The main purpose of this research is to produce android-based learning media products on trigonometric material that are valid and practical to use. The research conducted is development research with 4D models (define, design, development, dissemination). Participants in this study were grade X students of SMK. Data in the study were collected using questionnaires, consisting of expert validation questionnaires, and student response questionnaires as users. Based on the results of data analysis, the research conducted obtained a value of 75,50% for media experts and 75,60% for material experts with good categories. The next stage is a practicum test and questionnaire on a small scale which obtained a score of 75,17% with good and practicum categories. So it is concluded that Android-based learning media is feasible and practical to be used in mathematics learning. (Bilda et al., 2021)

Learning becomes more fun and not boring with supporting media, such as android. Android is an alternative to distance learning or online. With Android as a learning medium during a pandemic or distance learning. Lecturers will increasingly develop in the delivery of modern learning. Students will be more enthusiastic about receiving learning materials that are not boring.

A learning strategy can be interpreted as a plan that contains a set of activities designed to achieve specific educational goals. Learning strategy is the next step of the learning design process, namely, how to get to the learning process in question is a series of external events for students designed to improve the internal process of learning. There is another sense of learning strategy is an action plan or series of activities including the use of methods and the utilization of various resources or strengths in learning that are structured to achieve certain goals. According to

Mulyono &; Wekke (2018), learning strategies are a set of learning procedure materials that are used together to produce learning outcomes for students.

Suherman and Suryadi (2003), stated that mathematics learning strategies are tactics or tips that are deliberately planned by teachers, regarding all learning preparations so that the implementation of learning runs smoothly and goals in the form of learning outcomes can be achieved optimally. Learning strategies need to show the integrated use of mathematics in various problems, to make students understand that in real life often problems or symptoms contain various aspects so that the branches of mathematics can be used together to analyze the problem or phenomenon.

The design of making mathematics learning media is as follows:

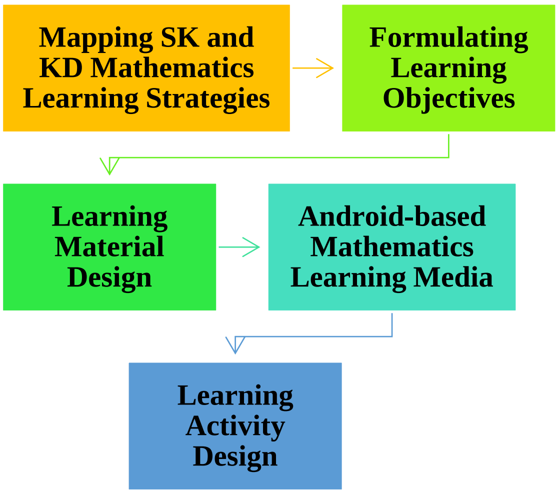


Figure 1. Android-Based Mathematics Learning Media Design Flowchart

METHOD

The research method used in this study is the research and development method (*Research and Development*). Producing a specific product and testing the effectiveness of the product is the main purpose of this method. So that the development of teaching materials is designed with research and development methods. (Sugiyono, 2013)

The research procedure is guided by the design of instructional media development by Borg &; Gall, namely the process of developing and validating educational products (Borg &; Gall, 1983 in A & Abdillah, 2019). The Borg & Gall (in Waris et al., 2018) model includes 10 stages of development outlined as follows: (1) determining potential and problems, (2) data collection, (3) product design, (4) design validation, (5) design revisions, (6) product trials, (7) product revisions, (8) usage trials, (9) product revisions, and (10) mass production or final product.

This model has development steps that are by educational research and development, namely research that produces or develops certain products by conducting several expert tests, such as material tests, design tests, and product trials in the field to test the attractiveness of a product.

Of the 10 stages, researchers only carry out stages 1 to 6, due to time constraints.

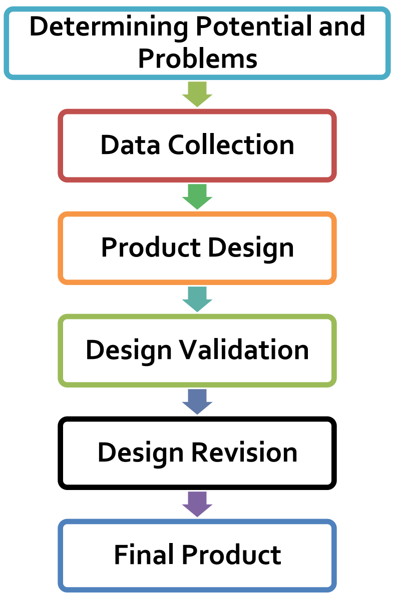


Figure 2. Procedure for Implementing Research Stages

Experiment Design

The trial design consists of several stages, namely: 1) Expert validation: 2) validation of android-based mathematics learning media design; 3) revision of android-based mathematics learning media design based on the assessment of 2 content experts and 2 android-based mathematics learning media design experts (stage I test); 4) testing Android-based mathematics learning media by 5 students (individual trials) and 10 students (small group trials; 5) product revisions (phase II trials); 6) field trials on students; and 7) design revision (phase III test).

Test Subjects

The test subjects are product users, namely fourth-semester (IV) students of the Mathematics Education Study Program, University of the Muhammadiyah North Sumatra. The implementation of the trial went through three stages, namely: (1) *Individual trials.* In this step, Android-based mathematics learning media has been revised based on suggestions from several experts. Assessment questionnaires are given to users individually to find out the validity of the product after it has been improved by a team of content and design experts. Input from individual trials is then used as a basis for making improvements to the product; (2) *Small group trials.* This trial is to find out if any flaws need to be corrected in the product after revisions from experts and individual trials. If there are any shortcomings, they will be revised; and (3) *Field trials.* This trial was conducted to find out whether there are still shortcomings that need to be corrected in Android-based mathematics learning media developed after discussions with a team of experts and the results of individual and small group trials.

In the implementation of research and development (R & D), researchers use two types of data collected, namely: (1) Data described in sentence form are qualitative data. Usually input and suggestions by validators and (2) Data processed with numbers is quantitative data. Usually a questionnaire assessment.

For student questionnaires that have participated in the implementation of product trials, the instrument used has 4 answers, so the total assessment score can be found using the following formula:

$$\bar{x} = \frac{\sum x}{n} \, x \, 4 \text{ (Yupinus et al., 2020)}$$

Description: $\bar{x}$: average rating | $\sum x$: umber of scores (questionnaire scores of each student | n : Number of students (maximum score)

The criteria for the assessment results of validators and test subjects are as follows: (Damayanti et al., 2018)

Table 1. Learning Media Feasibility Scale

Presentation	Criterion
81% – 100%	Very worth it
61% – 80%	Worthy
41% – 60%	Decent enough
21% – 40%	Not worth it
0% – 20%	Not really worth it

RESULTS AND DISCUSSION

Result

This research produces Android-based learning media in the Mathematics Learning Strategy course. Sugiyono's (2013) procedure method quoted from Borg and Gall which was carried out from stage 1 to stage 6 used in this research and development, among others:

Potential and Problems

Technological advances that can be used in learning, especially mathematics, will be potential in this research. Lecturers to be creative and innovative in delivering learning, especially in mathematics learning, are certainly required to see existing technological advances. Teaching that still uses the same method or learning model, namely lectures and besides that, there are limitations for lecturers to explain the material to students, because they still use a limited face-to-face system, so there is a reduction in course hours from 100 minutes to 60 minutes for 2 credits. Therefore, lecturers must innovate and be creative in learning so that students are not bored and bored in learning mathematics learning strategies.

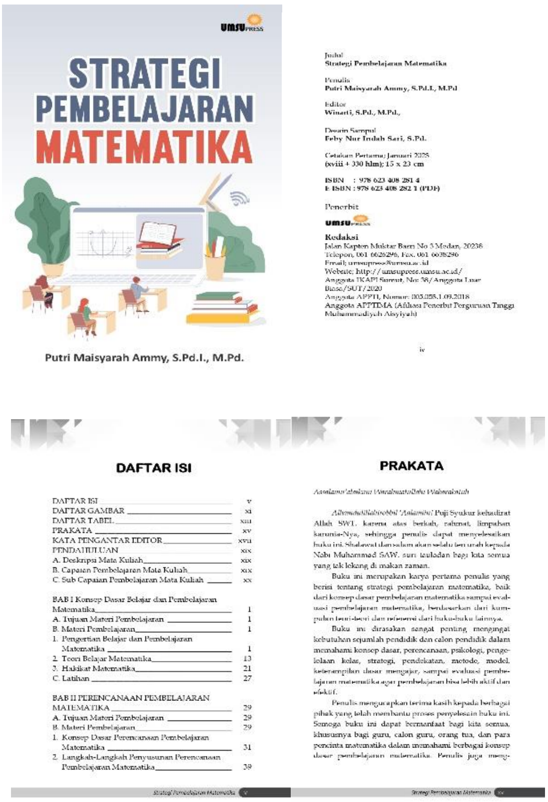
These problems and potentials make researchers design android-based learning media, namely using classroom applications in mathematics learning strategy courses so that learning is more effective and utilizes existing technology.

Collecting Data

In the process of designing this learning media, researchers collect information in the form of supporting theories for the design to be made. Researchers collect several books related to the subject and other sources relevant to the research. All this information or data is certainly related to the design of this Android-based learning media with classroom applications. Among its supporters are: Book: Creating Android Apps Without Coding with App Inventor (Komputer, 2013). To see how to create an android app.; Package the book: Mathematics Learning Strategies (Muhlisrarini, 2014). To create materials.; and Some journals, as relevant research.

The ideal book in lectures on mathematics learning strategies is as follows: (1) Includes systematics and writing structure, such as the purpose of the sub-chapters of the material written along with the explanation of the sub-chapters, examples, and exercises to reflect on students. (2) Completeness of the book discussion, meaning the content of the book by the title of the book made, as the book that the researcher designed with the title of mathematics learning strategies, then the content of the book includes strategies, methods, approaches, and so on about mathematics learning. Equipped with references (bibliography), glossary, about the author, and synopsis.; and (3) Pay attention to writing style, the writing style that researchers use is the language that is easily understood by students or readers. Written using fonts and spacing appropriate for reading.

One of the books on mathematical learning strategies designed by researchers:



Judul
Strategi Pembelajaran Matematika

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Editor
Winarti, S.Pd., M.Pd.,

Desain Sampul
Feby Nur Indah Sari, S.Pd.

Cetakan Pertama; Januari 2025
(xviii + 330 hlm); 15 x 23 cm

ISBN : 978 623 408 281 4
E-ISBN : 978 623 408 282 1 (PDF)

Penerbit
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Redaksi
Jalan Kapten Muktar Basri No 3 Medan, 20238
Telepon, 061 6626296, Fax. 061 6638296
Email; umsupress@umsu.ac.id
Website; http://umsupress.umsu.ac.id/
Anggota IKAPI Sumut, No: 38/Anggota Luar Biasa/SUT/2020
Anggota APPTI, Nomor: 005.058.1.09.2018
Anggota APPTIMA (Afiliasi Penerbit Perguruan Tinggi Muhammadiyah Aisyiyah)

iv

DAFTAR ISI

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PRAKATA

Assalamu'alaikum Warahmatullahi Wabarakatuh

Alhamdulillahirobbil 'Aalamiin! Puji Syukur kehadirat Allah SWT, karena atas berkah, rahmat, limpahan karunia-Nya, sehingga penulis dapat menyelesaikan buku ini. Shalawat dan salam akan selalu tercurah kepada Nabi Muhammad SAW, suri tauladan bagi kita semua yang tak lekang di makan zaman.

Buku ini merupakan karya pertama penulis yang berisi tentang strategi pembelajaran matematika, baik dari konsep dasar pembelajaran matematika sampai evaluasi pembelajaran matematika, berdasarkan dari kumpulan teori-teori dan referensi dari buku-buku lainnya.

Buku ini dirasakan sangat penting mengingat kebutuhan sejumlah pendidik dan calon pendidik dalam memahami konsep dasar, perencanaan, psikologi, pengelolaan kelas, strategi, pendekatan, metode, model, keterampilan dasar mengajar, sampai evaluasi pembelajaran matematika agar pembelajaran bisa lebih aktif dan efektif.

Penulis mengucapkan terima kasih kepada berbagai pihak yang telah membantu proses penyelesain buku ini. Semoga buku ini dapat bermanfaat bagi kita semua, khususnya bagi guru, calon guru, orang tua, dan para pencinta matematika dalam memahami berbagai konsep dasar pembelajaran matematika. Penulis juga meng-

Strategi Pembelajaran Matematika | xv

Figure 3. Book of Mathematics Learning Strategy

Product Design

The design of learning media will be carried out at this stage. Materials, assignments, UTS, UAS, student grades, and student attendance are part of the media to be designed. Researchers use classroom applications as android-based mathematics learning media. In addition, researchers also use textbooks on mathematics learning strategies designed by the researchers themselves.

Main course

Figure 4. Main Menu display

Figure 4 is the main menu that displays the number of classes to be taught, the class schedule, the number of students, and the name of the course being taught.

Forum Menu

Next, if you click on one of the classes in the main menu, the forum menu will appear, as shown below:

Figure 5. Forum Menu Display

Figure 5 shows the class name, course name, number of students, and class schedule, just like the previous main menu. The forum menu also displays the latest news or posts made by lecturers containing materials, attendance, assignments, as well as midterm exams, and final semester exams. In this menu, discussions can also occur between students and lecturers, by commenting on one of the posted contents.

Classwork menu

This menu contains materials, attendance, assignments, quizzes, and midterm exams, end-of-semester exams, as shown below:

Figure 6. One Semester Material

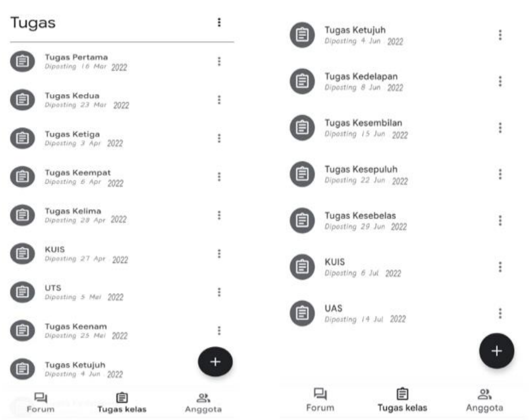

Figure 7. Tasks, UTS, UAS

Figure 8. Attendance List

Members Menu

The next menu is the member menu, where this menu contains the name of the teacher (lecturer) and the name of the student (student). The display results are as follows:

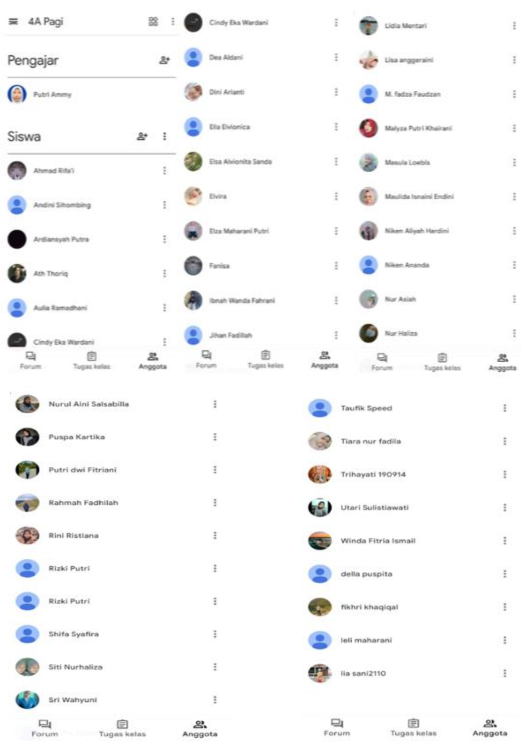

Figure 9. Members Menu

Materials, Tasks, UTS, and UAS

One view of materials, tasks, UTS, and UAS. Students can download materials directly and can also comment on materials, assignments, UTS, and UAS that they do not understand.

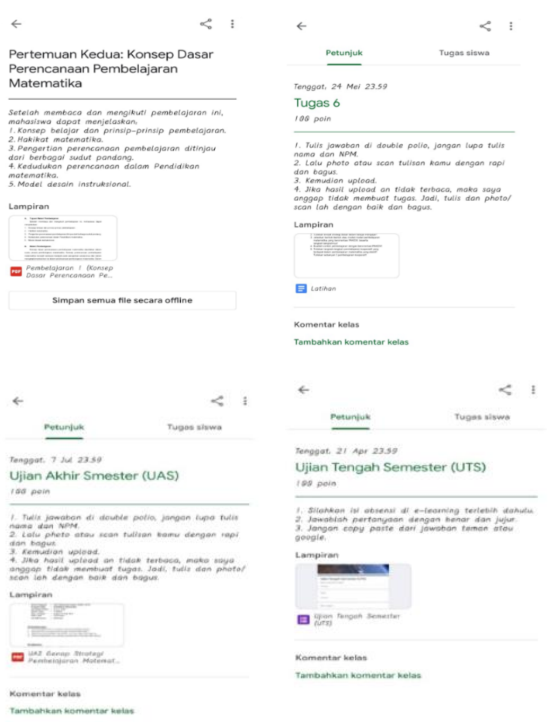

Figure 10. Display of Materials, Tasks, UTS, and UAS

Design Validation

The validity or feasibility of the media that has been designed will be tested so that the media can be entered or used at the trial stage. 5 experts will test this media, namely 3 material experts and 2 programming experts. Criteria in determining expert subjects, namely: (1) Experienced in their fields, (2) Minimum education S2.

Validation Results by Material Experts

Testing the completeness of the material, the correctness of the material, and the systematics of the material is the purpose of material expert validation. Presents the validation results as follows:

Table 2 Results of Phase 1 Validation by Material Experts

No	Aspects	Average Score	Information
1.	Theory	3,4	Valid
2.	Discussion	3,2	Quite valid
3.	Evaluation	3,16	Quite valid

Because the media is still in the Quite Valid criteria, it is partially corrected. If the revision has been completed, then revalidation is carried out by material experts, the results are as follows:

Table 3 Results of Stage 2 Validation by Material Experts

No	Aspects	Average Score	Information
1.	Theory	3,73	Valid
2.	Discussion	3,64	Valid
3.	Evaluation	3,66	Valid

Data Source: Processed from the results of expert validation assessment questionnaires for Android-Based Learning Media in Mathematics Learning.

The scores obtained in stage 2 validation obtained 3,73 highest scores, and 3,64 lowest scores with each achieving the "Valid" criterion.

Validation Results by Media Experts

Graphical testing of android-based learning media in mathematics learning is the goal of this media expert validation. The validation results are as follows:

Table 4 Validation Results by Media Experts

No	Aspects	Average Score	Information
1.	Media Efficiency	3,87	Valid
2.	Button Functions	3,5	Valid
3.	Graphics	3,4	Valid

Data Source: Processed from the results of the Android-based Learning Media Questionnaire in mathematics learning.

The expert validation results earned the highest score of 3,87 and the lowest score of 3,4 with each achieving the "Valid" criterion.

Design Revision

After the product design is validated through the assessment of material experts and media experts, researchers revise the product design developed based on expert input. Where this stage is the final stage of the research stage. Because the results of small-group trials and large-group trials have been said to be interesting and feasible by validators, it can be concluded that the media that has been designed meets the standards of the attractiveness of learning media.

Design Trials

Design trials are conducted after the media is improved with suggestions and input provided by validators. 15 small group students and 42 large group students were used by researchers in testing this design. The results of the trial are as follows:

Table 5 Small Group Trial Results

Number of Respondents	Average score	Criterion
10	3,65	Very Interesting

Data Source: Processed from the results of the Small-Scale Field Trial Assessment Questionnaire.

Involving 10 students of grade 4A Morning, especially students of the Mathematics Study Program FKIP Semester 4, resulted in an average score of 3,65 with the criteria "Very Interesting". Hereby it is stated that the designed media has attractive criteria to be used as an aid in learning activities in mathematics learning strategies.

Table 6 Results of Large Group Trials

Number of Respondents	Average score	Criterion
58	3,51	Very interesting

Data Source: Processed from the Results of a Large-Scale Field Trial Assessment Questionnaire.

Involving 42 students of grade 4A Morning, especially students of the Mathematics Study Program FKIP Semester 4, resulted in an average score of 3,51 with the criteria of "Very Interesting". Hereby it is stated that the designed media has attractive criteria to be used as an aid in learning activities in mathematics learning strategies for mathematics.

Discussion

This study aims to design android-based mathematics learning media in mathematics learning strategy courses.

The media designed in this study is an application on Android, namely Classroom. This application provides various features, such as being able to make learning videos, book files, or materials that can be sent and can be read by all students and can discuss and ask directly to the lecturer if anyone does not understand or discuss with other friends. This application can be used by anyone if they have access, or a code given by the lecturer. This application can be opened using a smartphone or laptop.

The problem that occurs on campus is that students are bored and bored with the usual learning model or method (lecture), so it requires a lecturer to be able to innovate and be creative in making learning media. This android-based learning media can be one of the learning media for smoothness in the learning process, especially in mathematics learning strategy courses.

After the learning media design is completed, the learning media is validated by material experts and media experts. Based on the results of validation that have been carried out by a team of material experts and media experts, it is stated that android-based learning media has a very interesting category to be presented to students to be used as learning media in mathematics learning strategy courses.

Android-based learning media is feasible and practical because it can be used anywhere (Bilda et al., 2021) It is proven that during the Covid-19 pandemic, which causes learning cannot be carried out face-to-face and carried out online, this android-based learning media is very helpful in learning (Siregar et al., 2021)

Can test students' perceptions of the use of digital technology in formal learning, and test their differences in perceptions of the use of digital technology in formal learning, based on gender, age, major, academic year, perception of digital competence, and perception of digital dependence (Dyah, 2014). By using android, it can create comics to make learning more interesting (Utomo et al., 2020)

In addition to android-based learning media, there is also a blended learning model that uses the Edmodo application (Wati & Sudarma, 2020). By using an android or smartphone with a Realistic Mathematics Education (RME) approach, you can develop a mathematics e-module (Fahmi et al., 2022)

To improve students' assessment and self-understanding, they can use Mathbox media developed with the Codular website (Ulfa et al., 2023). The advantages and disadvantages of android-based learning media are: (1) Excess: Easy to use, attractive, and simple; Learning can be anywhere; The size of the device is small and lighter than a laptop or computer; and (2) Deficiency: Need android with high enough specifications; Always connected to the internet; The battery drains quickly. (Kuswanto & Radiansah, 2018)

Limitation

The limitation of this study is that not all students have smartphones with high specifications or RAM. As well as the limited time of researchers, this research is only up to the production of learning media design. In addition, this research can produce android-based learning media that facilitate learning during distance learning and can make innovations or alternative learning media so that the method used is not just a lecture method.

Implication

It is hoped that the results of this research can provide information to lecturers to design or develop Android-based learning media for other materials or subjects and provide a choice of teaching methods in higher education to increase enthusiasm for learning and eliminate student boredom while studying.

I would like to thank the Department of Mathematics Education, Faculty of Teacher Training and Science, Universitas Muhammadiyah Sumatera Utara and LPPM for providing support for this research.

CONCLUSION

Based on the results of the research described earlier, several conclusions can be drawn as follows: The development of mathematics learning media in mathematics learning strategy courses using Android media was developed with the characteristics of learning media, namely, to arouse student learning enthusiasm, more interactive (can be applied in distance learning), more flexible, easy to use (can be read anywhere), and overcome space and time limitations.

The development of android-based mathematics learning media starts from looking for potential and existing problems, then collecting information about the media needed through interviews with students who are researched and pre-existing research (relevant), after that an appropriate product design is carried out from the results of information collection. The next stage, design validation by material experts and media experts is then improved (revised) design by the input of material experts and media experts, the last stage, is design trials, at these stage two trials are carried out, the first is small-scale trials and large-scale trials.

Reviewing the results of media validation that has been developed, there is an average score of 3.73 obtained from media experts and an average score of 3.87 obtained from material experts. Each of the criteria possessed is valid or feasible. The responses obtained from students obtained 3.65 average scores on small group tests and 3.51 average scores on large group tests. The criteria obtained by each of them are very interesting.

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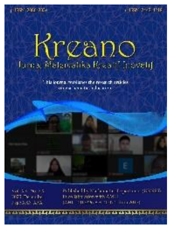
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 243-253



Analysis of Students' Computational Thinking Skills on Social Arithmetic Material in Terms of Adversity Quotient

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Abstract

This research fills an urgent knowledge gap regarding the urgency of analyzing students' computational thinking skills in today's learning. In an era where technology and computing play an important role in daily life, computational thinking skills are crucial for students to face future challenges. Although there have been previous studies on students' computational thinking skills and its influencing factors, there is no adequate understanding on how AQ can affect students' computational thinking skills, especially in the context of social arithmetic learning. This research aims to fill the knowledge gap and analyze how AQ can influence students' computational thinking skills in the context of social arithmetic learning. Through a descriptive qualitative approach, involving 20 students from class VII B MTS Annuriyyah Jember as research subjects. Data were validated using triangulation techniques, namely AQ questionnaire, test and interview. Using AQ questionnaire, the results showed that there were 3 students with Climbers type (high AQ), 14 students with Campers type (medium AQ), and 3 students with Quitters type (low AQ). From each AQ type, three students were selected for further analysis related to their computational thinking ability. The results showed that students with high AQ type were able to fulfill all indicators of computational thinking ability. Students with moderate AQ type were able to identify important information and organize the solution steps, although there were some steps that were not appropriate. However, they were still able to solve the problem correctly. On the other hand, students with low AQ type were unable to record the required information and failed to organize the solution steps properly, resulting in an incorrect solution. Overall, this study showed that students' computational thinking ability in social arithmetic varied depending on their AQ type. The findings indicate a relationship between Adversity Quotient and students' computational thinking skills, which can be used to develop more effective learning strategies and motivate students in learning mathematics.

Keywords*: Computational thinking skills, Adversity Quotient, social arithmetic*

Information of Article

Subject classification	*97C30 Cognitive processes, learning theories (aspects of mathematics education)*
Submitted	*19 June 2023*
Review Start	*20 June 2023*
Initial Review Finish	*20 June 2023*
Round 1 Finish	*12 July 2023*
Round 2 Finish	*31 July 2023*
Accepted	*31 July 2023*
Published	*13 September 2023*
Similarity Check	*6%*

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Abstrak

Penelitian ini mengisi kesenjangan pengetahuan yang mendesak terkait urgensi menganalisis keterampilan berpikir komputasional siswa dalam pembelajaran saat ini. Dalam era dimana teknologi dan komputasi memainkan peran penting dalam kehidupan sehari-hari, kemampuan berpikir komputasional menjadi sangat penting bagi siswa untuk menghadapi tantangan masa depan. Meskipun telah ada penelitian sebelumnya mengenai keterampilan berpikir komputasional siswa dan faktor-faktor yang mempengaruhinya, belum ada pemahaman yang memadai mengenai bagaimana AQ dapat mempengaruhi kemampuan berpikir komputasional siswa, terutama dalam konteks pembelajaran aritmatika sosial. Peneitian ini bertujuan untuk mengisi celah pengetahuan tersebut dan menganalisis bagaimana AQ dapat mempengaruhi keterampilan berpikir komputasional siswa dalam konteks pembelajaran aritmatika sosial. Melalui pendekatan deskriptif kualitatif, dengan melibatkan 20 siswa dari kelas VII B MTS Annuriyyah Jember sebagai subjek penelitian. Data divalidasi menggunakan triangulasi teknik, yaitu angket AQ, tes dan wawancara. Melalui penggunaan angket AQ, didapatkan hasil bahwa terdapat 3 siswa dengan tipe Climbers (AQ tinggi), 14 siswa dengan tipe Campers (AQ sedang), dan 3 siswa dengan tipe Quitters (AQ rendah). Dari masing-masing tipe AQ tersebut, tiga siswa dipilih untuk dilakukan analisis lebih lanjut terkait kemampuan berpikir komputasional mereka. Hasil penelitian menunjukkan bahwa siswa dengan tipe AQ tinggi mampu memenuhi semua indikator kemampuan berpikir komputasional. Siswa dengan tipe AQ sedang telah mampu mengidentifikasi informasi penting dan menyusun langkah-langkah penyelesaian, meskipun terdapat beberapa langkah yang tidak sesuai. Namun, mereka masih mampu menyelesaikan permasalahan dengan benar. Di sisi lain, siswa dengan tipe AQ rendah tidak mampu mencatat informasi yang dibutuhkan dan gagal menyusun langkah-langkah penyelesaian dengan baik, sehingga menghasilkan solusi yang salah. Secara keseluruhan, penelitian ini menunjukkan bahwa kemampuan berpikir komputasional siswa dalam materi aritmatika sosial bervariasi tergantung pada tipe AQ mereka. Temuan ini mengindikasikan adanya hubungan antara Adversity Quotient dan keterampilan berpikir komputasioal siswa, dapat digunakan untuk mengembangkan strategi pembelajaran yang lebih efektif dan memotivasi siswa dalam pembelajaran matematika.

INTRODUCTION

The development of the times in the current era of globalization requires an increase in the ability or skills needed to solve global challenges. In Indonesian education, the challenge is important in creating a dynamic and strategic curriculum while following the development of technology in this 5.0 era (Danindra, 2020). The improvement of the quality of mathematics education also needs to be improved. Because mathematics is considered as one of the basic sciences that are widely used to study other fields of science (Afifah et al., 2023). One of the purposes of learning mathematics is to acquire a person's thinking and reasoning skills to enable a person to confidently and honestly form opinions and draw conclusions when facing problems (Bernard, 2015). One of the skills that can be improved in the thinking process is computational thinking skills. Computational thinking skills are basic abilities that involve various fields, including in education to solve mathematical problems and understand basic concepts in computer science (Wing, 2017).

Computational thinking skills provide benefits for humans to be able to solve problems by designing a system that we cannot do by ourselves (Nugraha et al., 2023). Therefore, applying mathematical concepts in real life is an important part of developing computational thinking skills. Rijal Kamil et al., (2021) also argue that computational thinking skills are important skills for individuals to solve their daily problems. This is in line with Christi & Rajiman, (2023) that the importance of computational thinking skills in the world of computing lies in its ability to develop individuals' critical, creative, and analytical thinking skills in solving complex problems, both in the scope of computing and in real life.

An example of the application of computational thinking skills in mathematics is when students must solve problems involving numerical calculations and mathematical operations in the context of daily life. For Example, when students are asked to calculate the total cost of purchasing several items with different prices, they need to use computational thinking skills to identify the right calculation steps and process the given data. This ability enables students to solve mathematical problems effectively and apply mathematical concepts in real-life situations.

One of the most important mathematics areas that students understand and is closely related to daily life is social arithmetic. through social arithmetic material, students can increase a deeper understanding of mathematical concepts by applying problem solving in real-life contexts. Khairunnisa & Setyaningsih, (2017) also agree that to be successful in solving social arithmetic problems, students need to have the ability to read and understand the problem and be able to determine the right steps to solve the problem.

The results of studies related to students' computational thinking skills show suboptimal results. Teachers often faced the fact that most students have difficulty in solving math problems when studying in class. In the research of Shufah & Izzah, (2022) explained that this happens because there are still many students who have difficulty working on problems that require a lot of high-level thinking skills, such as questions about how mathematics can be used in everyday life. As a result, students' interest in improving computational thinking skills is low. Therefore, it is important to improve the ability to think computationally as the low impact of this ability affects student learning outcomes (Sa'diyyah et al., 2021).

There are four operational skills in computational thinking, those are decomposition or identifying problems, pattern recognition, abstraction and algorithmic thinking (Marifaha & Kartono, 2023). By developing these four skills, students can improve their computational thinking skills as well as apply mathematical understanding in problem solving (Mubarokah et al., 2023). However, to improve students' computational thinking skills more effectively, it is also necessary to consider other factors that can influence students' learning success, including Adversity Quotient (AQ) ability. Adversity Quotient describes the extent to which a person can overcome challenges, obstacles, and hurdles in his or her life. This is because the need to consider AQ is important in improving student learning success (Chabibah et al., 2019).

Adversity Quotient is the personal intelligence in solving problems or facing challenges, and can be interpreted as an individual's fighting power (Wahyuni et al., 2022). AQ also involves intelligence and skills in changing, processing, and dealing with problems or difficulties, and turning them into challenges that can be overcome and resolved (Hidayah et al., 2016). Adversity Quotient can affect students' attitudes, motivation, and resilience in facing learning difficulties, including in solving mathematics problems involving the concept of computational thinking. This is due to the different levels of Adversity Quotient that each student has in facing problems (Abdiyani et al., 2019).

There are 3 levels of adversity quotient, namely quitters, campers, and climbers (Maini & Izzati, 2019; Nuraini et al., 2018). Students who belong to the quitters type tend to tend to give up easily, be passive, and lack motivation in solving problems. They may tend to give up quickly when facing difficulties. Students who belong to the campers type, on the other hand, endeavour to overcome the problems they face. However, they may not achieve the maximum level of success and tend to feel satisfied with what they have achieved. Students who belong to the climbers type always endeavour to achieve full success. They have strong motivation and are highly committed in solving the problems they face. They do not give up easily and keep trying to achieve better and higher results (Shufah & Izzah, 2022). Stoltz also explained that individuals with high AQ will continue to try to complete the tasks given despite facing difficulties (Wahyuni et al., 2022). In improving students' computational thinking skills, keep in mind that motivation and a positive mental attitude are very important. Students need to be encouraged to have a persistent attitude, dare to face challenges, and have high motivation in solving computational problems. With the grouping of adversity quotients, it is possible to predict how a person responds to mathematical problems (Mafulah & Amin, 2020).

Based on the previous explanation, each student has a different level of Adversity Quotient which can affect their skills in computational thinking. This information can be used to improve the mathematics learning process. Therefore, the purpose of this study is to further investigate the computational thinking skills of students at MTS Annuriyah on social arithmetic material in terms of Adversity Quotient.

METHOD

This research used a qualitative descriptive method. In this study, researchers had provided a description of students' computational thinking skills on social arithmetic material in terms of Adversity Quotient. The research subjects consisted of 20 students of class VII B MTS Annuriyah Jember. They were selected based on their AQ type. There are 3 subjects from class VII B who have high AQ, medium AQ, and low AQ categories, there is one student at each level. The data collection techniques used were questionnaire of Adversity Quotient, computational thinking skills test, and interview. Data from the AQ questionnaire was used to categorise students into Adversity Quotient types. The computational thinking skills test was conducted to determine the level of students' computational thinking skills. And the interview was conducted once when students finished doing the test with the aim of describing the test results that had been done and strengthening the test results.

In analysing the data, the researcher used the Miles and Huberman (2013) model including 3 stages: (1) data reduction, (2) data display, and (3) inference. In the data reduction stage, the data that had been collected from the AQ questionnaire and computational thinking skills test were reduced and arranged to enable researchers to understand the relevant information. Furthermore, the data display stage, the data that has been reduced is then arranged in a certain way, namely through tables or interview quotes, the purpose of data display is to provide a clear picture of the research findings. The last stage is the Inference stage, where Inference is done to interpret the data and make conclusions based on the analysis that had been done, in this case the researcher would describe the types of AQ and the level of computational thinking skills of class VII B students at MTS Annuriyah Jember based on the data that had been analysed. The research instrument used was a 20-item AQ questionnaire adopted from the thesis of PUTRA, (2021) which had been tested and validated and 2 items of story problems designed according to the indicators of computational thinking skills. These indicators could be seen in table 1. In addition, by triangulating to validate the data, namely by triangulating sources and methods.

Table 1: Indicators of computational thinking skills

Indicators of computational thinking	Indicators of competence
Decomposition	Students can identify and describe information related to the given problem
Pattern recognition	Students can find similar or different patterns used in solving problems.
Abstraction	Students can eliminate irrelevant elements in the problem solving plan to reach a conclusion.
Algorithmic thinking	Students can explain logical and systematic steps to find solutions to the problems given.

RESULTS AND DISCUSSION

Research Result

Student AQ questionnaire test results

The results of the classification of students in each AQ type can be seen in Table 2.

Table 2. AQ questionnaire results

Category	The number of students
High	3
medium	14
Low	3

In Table 2, from the 20 students who became research subjects, there were 3 students who were in the high AQ category, 14 students were in the medium AQ category, and 3 students were in the low AQ category. Research subjects were selected based on the AQ questionnaire scores obtained. The difference in the number of students in each category can be influenced by various factors. The tendency for more students in the moderate AQ category is due to a more even distribution of social sensitivity and emotional responses to mathematics problems among most students. This suggests that most students have a rather balanced response to the mathematics tasks given by the teacher, and they feel challenged to complete them. Meanwhile, the high and low AQ categories with fewer students may reflect more unique traits in terms of students' emotional responses and motivation levels towards mathematics. Students with high AQ showed very high levels of confidence and interest in mathematics, while students with low AQ showed challenges in dealing with mathematical difficulties and needed additional support. In this study, 1 student for high AQ, 1 student for medium AQ, and 1 student for low AQ were selected. The selection of one student from each category in this study aims to understand more deeply the differences in characteristics and behaviour that may occur between these AQ categories.

After the subject was selected, the researcher analysed the students' computational thinking skills on social arithmetic material in terms of AQ. The following is a description of students' computational skills in solving problem number 1 on social arithmetic material in terms of AQ.

The questions used in this study are: At a wedding, there were 350 guests present. Of these guests, 40% are the groom's family, 30% are the bride's family, and the rest are friends of the bride and groom. If the groom's family is 140, how many guests are friends of the bride and groom?

S1 computational thinking skills with high AQ type

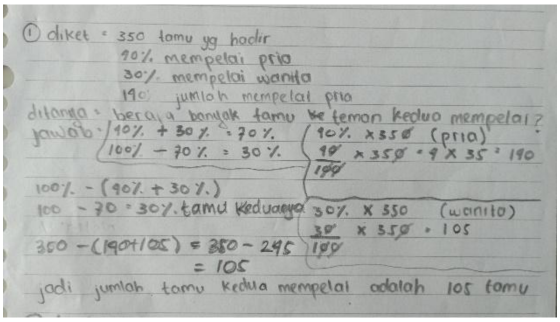

Figure 1: Answer S1 of high AQ type

Based on the data obtained from Figure 1, students are very thorough and detailed in solving the problem correctly and precisely. After analysing the students' answer sheets including identifying students' computational thinking skills in solving social arithmetic problems, it can be obtained that students are able to write the main problem and write down what facts are needed by the problem. This is supported by the results of interviews with students with high AQ types.

T : What information do you know?
S1 : 350 guests attended, 40% were the groom's family, 30% were the bride's family, the groom's family numbered 140.
T : Then what is asked in the question?
S1 : Here ma'am, how many guests are friends of the bride and groom?
T : How do you find out the information?
S1 : I read the question first ma'mm, then I know what is known in the question.
T : Then how did you calculate it?
S1 : So first calculate the percentage of male and female families. Here I use two methods. First, the percentage is 100%, right, I subtract 40% + 30%, the result is 30%. That's where I found 105 guests whose percentage is 30%. To prove it 350 - (140+105) so I found the friends of the bride and groom 105 guests.
T : After doing it, do you check the result again?
S1 : Yes ma'am, I checked the result again and calculated it again. Because to make sure the answer I wrote is correct

Through the interview excerpt above, S1 was able to perform the decomposition stage by identifying and describing information related to the problem given. S1 recognised that the relevant information included the number of guests present 350, the percentage of the groom's family 40%, the percentage of the bride's family 30%, and the number of the groom's family given 140 people. This decomposition ability helped S1 in deeply understanding the problem to be solved.

Furthermore, S1 can perform pattern recognition. S1 was able to identify similar or different patterns used in the problem solving process. In this problem, the pattern found was the use of percentages in calculating the number of groom's family and bride's family. S1 realised that this calculation was key in solving the problem.

As for the abstraction stage S1 can eliminate irrelevant elements in the problem solving plan. They focus on calculating the number of the groom's family, the number of the bride's family, and the number of friends of the bride and groom. S1 can ignore other elements such as the gender of the bride and groom or additional information that is irrelevant in finding a solution.

Finally, S1 was able to explain the logical and systematic steps to find the solution to the problem. They used structured and organised algorithmic thinking steps. First, S1 calculated the number of the groom's family by multiplying the percentage of the groom's family 40% by the number of guests present 350. Next, S1 calculated the number of the bride's family by multiplying the percentage of the bride's family 30% by the number of guests present 350. Finally, S1 reduced the total number of guests 350 by the number of the groom's family 140 and the number of the bride's family 105 to get the number of friends of the bride and groom, namely 105 guests.

In solving this problem, S1 fulfils all indicators of computational skills. Hidayat & Sariningsih, (2018) in their research stated that students with high AQ have a good understanding of the problem, can plan the solution steps, are able to check by writing down how to verify the results and process. This shows that students with the ability of climbers can solve mathematics problems, that students are very confident that every problem can be solved, they do not give up easily and remain optimistic in facing difficulties in achieving success or finding the right answer (Yanti & Syazali, 2016).

S2 computational thinking skills with moderate AQ type

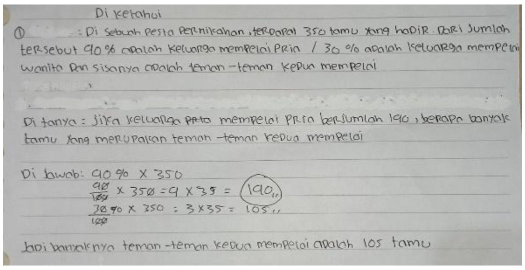
Di ketahui
① : Di sebuah pesta pernikahan, terdapat 350 tamu yang hadir. Dari jumlah tersebut 40% adalah keluarga mempelai pria / 30% adalah keluarga mempelai wanita dan sisanya adalah teman-teman kedua mempelai
Di tanya : jika keluarga mempelai pria berjumlah 140, berapa banyak tamu yang merupakan teman-teman kedua mempelai
Di jawab: 40% x 350
40/100 x 350 = 4 x 35 = 140
30/100 x 350 = 3 x 35 = 105
Jadi banyaknya teman-teman kedua mempelai adalah 105 tamu

Figure 2. S2 answer of medium AQ type.

Based on the data obtained from Figure 2 and from the results of the interviews conducted with S2, it can be concluded that in understanding the problem S2 can describe the known information in the form of the number of guests present 350, the percentage of the groom's family 40%, and the percentage of the bride's family 30%. And S2 is also able to write the information asked in full, namely how much is the total number of the bride and groom. This is supported by the results of the interview with S2 who was able to provide information on the problem in detail. This shows that S2 uses a decomposition approach in his thinking process.

Next, in the second stage, namely pattern building, where S2 showed by finding a percentage calculation pattern. S2 knows that the percentage of the groom's and bride's family must be calculated first to reach an accurate solution.

Students' abstraction skills were also seen when S2 eliminated irrelevant elements in the problem solving plan. S2 focused the calculation on the groom's family, the bride's family. However, S2 did not explain the calculation to the friends of the bride and groom, where S2 immediately concluded the result of the bride and groom's guests totalling 105 people.

In explaining the logical and systematic steps to find a solution, S2 has not succeeded in showing overall algorithmic thinking skills. S2 has not been coherent in calculating the number of families of the bride and groom based on the percentage given. S2 did not reduce the total number of guests by the number of the groom's and bride's families to find the number of friends of the bride and groom but went straight to the conclusion of the result.

In solving this problem, S2 did not fulfil all indicators of computational skills. In a study conducted by Hidayat & Sariningsih, (2018) it was explained that students with AQ campers in solving problems have the ability to understand the problem, plan a solution, and implement the plan. Although the student's writing is incomplete.

S3 computational thinking skills with low AQ type

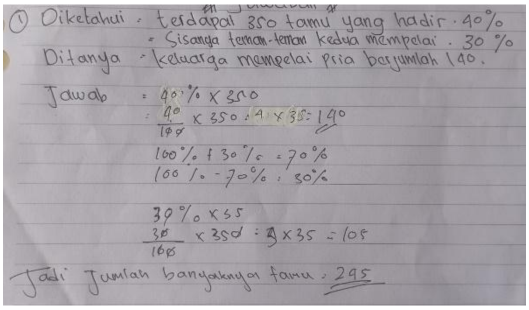
① Diketahui : terdapat 350 tamu yang hadir. 40%
: Sisanya teman-teman kedua mempelai. 30%
Ditanya : keluarga mempelai pria berjumlah 140.
Jawab : 40% x 350
: 40/100 x 350 = 4 x 35 = 140
100% + 30% = 70%
100% - 70% = 30%
30% x 35
30/100 x 350 = 3 x 35 = 105
Jadi jumlah banyaknya tamu : 295

Figure 3. S3's answer of medium AQ type

Based on the data obtained from Figure 3 and the results of interviews with S3, S3 can perform the decomposition stage by showing that S3 is only able to write down the known elements, namely the number of guests present 350, although there are some elements that are less precise. The subject should have written the percentage of the groom's family 40%, the percentage of the bride's family 30% and the number of the groom's family given 140 people. And S3 was also unable to write the information asked correctly.

Next in the second stage is pattern making, where S3 shows by finding a percentage calculation pattern. S3 knows that the percentage of the groom's and bride's family must be calculated first to reach the right solution. However, S2 did not explain the calculation on the friend of the bride and groom,

The next stage in computational thinking, namely abstraction and algorithmic thinking, which has not been achieved by S3. Errors made by S3 in recognising patterns affect his ability to reach this stage. Abstraction involves the ability to identify common patterns and generalise the solutions found. However, S3 has not succeeded in achieving abstraction because he made mistakes and could not draw the right conclusions about the solution he found. In addition, the indicators of thinking algorithms have also not been fulfilled by S3. Algorithmic thinking involves logical and systematic problem solving steps. However, the steps taken by S3 were inconsistent and did not fulfil these criteria. Errors and inconsistencies in the algorithm used by S3 hindered his ability to reach the algorithm thinking stage in computational thinking.

Discussion

Based on the analysis of the computational thinking process of the three students, it can be concluded that in solving social arithmetic story problems, students' computational thinking skills vary depending on their AQ type. Students with high AQ type, such as S1, have excellent computational thinking skills. They were able to fulfil all indicators of computational thinking, including decomposition, pattern recognition, abstraction, and algorithmic thinking. High AQ students tend to be able to identify and decompose information appropriately, including relevant elements in the problem. Their decomposition ability is very good, so they can answer the questions completely and accurately. Septianingtyas & Jusra, (2020) explained in their research, students with high AQ levels tend to have better problem solving skills, unyielding nature, and like challenges according to their AQ level. Students with moderate AQ types, such as S2, are also able to solve problems correctly. Although their decomposition and pattern recognition skills are better than those of low AQ students, they are not as clear and precise as those of high AQ students. Their abstraction and algorithmic thinking skills have also started to develop but need further development to reach a higher level. In accordance with the research of Septianingtyas & Jusra, (2020) the type transition from climber to camper (moderate AQ) shows a fairly good ability to carry out the stages of problem solving, although it is not as good as the climber stage, which means that there are indicators that are not carried out by the camper type and students are less careful in their work. Whereas students with low AQ types, such as S3, have challenges in computational thinking. Their decomposition ability still needs further development, so relevant information from the problem is not always included appropriately in the answer. Their pattern recognition is limited to simple patterns, and they struggle to identify more complex patterns. Their abstraction and algorithmic thinking skills are also still limited, so the problem-solving steps taken are not consistent and systematic. These students did not reach the correct answer and appeared to have difficulty in applying computational thinking skills in solving social arithmetic problems. Shufah & Izzah, (2022) in their research explained that students with low AQ levels (quitters), only fulfilled 1 indicator of computational thinking skills, this is because low AQ students do not have sufficient understanding in applying the correct steps in solving problems and have difficulty in applying computational thinking skills. Overall, students' computational thinking skills in social arithmetic varied depending on their AQ type. Students with high AQ type have better skills, while students with medium and low AQ type still need further development. In line with Rosita & Rochmad, (2016) When facing difficulties in solving mathematical problems, students who belong to the camper and climber categories will continue to try to find solutions. On the other hand, students who belong to the quitter category give up more easily and have less strong motivation to try to solve the problem.

Limitation

This research is limited to analysing students' computational thinking skills in social arithmetic with a review of Adversity Quotient (AQ). Social arithmetic is the focus of this research, where students are expected to understand and apply mathematical concepts in the context of everyday life. The concept of computational thinking skills that is of concern in this study includes students' understanding in solving mathematical problems, their ability to analyse problems computationally, as well as the creativity and innovation shown in formulating mathematical solutions. This research is limited to identifying the level of computational thinking skills of seventh grade students in social arithmetic and its relationship with the types of AQ possessed by students.

Another limitation is the limited sample size of the study. The use of this relatively small sample may affect the representation of variations in students' overall computational thinking skills. As such, generalisations of the results of this study should be made with caution and only apply to student populations in the same school.

Implication

This research has a function to recognise the computational thinking skills that occur in students, when learning social arithmetic. By recognising students' computational thinking skills when learning social arithmetic, teachers can better understand students' individual needs and challenges in dealing with mathematical problems.

The results of this study provide valuable guidance for educators in developing more effective and targeted learning strategies. Teachers can identify students with high, medium, and low AQ types, so that they can accommodate the differences in student characteristics with the right approach. Learning plans that are tailored to students' computational thinking abilities will help improve students' understanding and performance in mathematics subjects, especially social arithmetic.

CONCLUSION

Based on the research and discussion that has been done, it can be concluded that the analysis of students' computational thinking skills in social arithmetic material in terms of Adversity Quotient (AQ). Of the 20 students who filled out the AQ questionnaire, there were 3 students with high AQ type, 14 students with medium AQ type, and 3 students with low AQ type. Students with high AQ type showed good skills in all indicators of computational thinking skills. They were able to fulfil all the requirements and indicators proposed. Students with moderate AQ type have been able to identify important information and develop solutions in computational thinking problems. However, there were some steps that were not in accordance with the requirements and were unable to solve the problem correctly. On the other hand, students with low AQ type could not write down the required information and organise the solution steps well. Their skills in solving computational thinking problems were still limited. Overall, students' computational thinking skills in social arithmetic varied depending on their AQ type. Students with high AQ type have better skills, while students with medium and low AQ type still need further development. therefore, it is necessary to make additional efforts to assist students with medium and low AQ type in improving their computational thinking skills in the context of social arithmetic.

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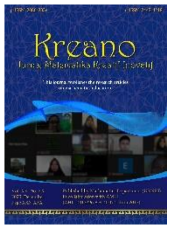
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 254-266



Analysis of Creative Thinking and Curiosity in X Class Students

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Abstract

In the learning, because the learning time isn't sufficient to convey material, teacher who concerned learning results than learning process made students just imitating teachers' problem solving. They aren't trained to solve new problems. This research aims, (1) finds out the mathematics creatie thinking ability of high school students; (2) finds out the characters of the students' curiosity; (3) finds out the influence of curiosity on students' creative thinking ability. This research method and design is a quantitative and comparison of approaches. The research is conducted at one of the state high schools in Semarang. The research population sample in a row is all students of classes of X MIPA and X MIPA 3. This population is given a creative thinking ability test. This sample is given a curiosity questionnaire. Creative thinking ability mean of the ten classes of X MIPA is 69,4. Curiosity mean of X MIPA 3 is 169,3. Therefore, (1) students' mathematics creative thinking ability is not optimal; (2) the character of the students' curiosity is not optimal; (3) curiosity positively affects creative thinking ability. That resulted in teacher developing learning media and processes and students' curiosity to their students' creative thinking ability.

Keywords: Creative Thinking; Curiosity.

Information of Article

Subject classification	*97C30 Cognitive processes, learning theories (aspects of mathematics education)*
Submitted	*19 June 2023*
Review Start	*20 June 2023*
Initial Review Finish	*20 June 2023*
Round 1 Finish	*12 July 2023*
Round 2 Finish	*31 July 2023*
Accepted	*31 July 2023*
Published	*18 November 2023*
Similarity Check	*10%*

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Abstrak

Dalam pembelajaran, karena waktu pembelajaran tidak mencukupi untuk menyampaikan materi, guru mengutamakan hasil dari pada proses pembelajaran mengakibatkan siswa meniru proses pemecahan masalah dari guru dan tidak terlatih menyelesaikan masalah baru. Tujuan penelitian, (1) mengetahui kemampuan berpikir kreatif matematis siswa SMA; (2) mengetahui karakter rasa ingin tahu siswa; (3) mengetahui pengaruh karakter rasa ingin tahu terhadap kemampuan berpikir kreatif siswa. Penelitian menggunakan metode penelitian kuantitatif. Desain penelitian adalah comparison of approaches. Penelitian awal dilaksanakan di salah satu SMA Negeri di Semarang. Populasi dan sampel penelitian berturut-turut adalah seluruh siswa kelas X MIPA dan X MIPA 3. Populasi diberikan tes kemampuan berpikir kreatif. Sampel diberikan angket curiosity. Rata-rata kemampuan berpikir kreatif dari 10 kelas X MIPA adalah 69,4. Rata-rata rasa ingin tahu siswa kelas X MIPA 3 adalah 169,3. Kesimpulannya (1) kemampuan berpikir kreatif matematis siswa belum optimal dalam pembelajaran, karena guru menyusun pembelajaran matematika belum terfokus pada kemampuan berpikir kreatif; (2) karakter rasa ingin tahu siswa belum optimal; dan (3) karakter rasa ingin tahu berpengaruh positif terhadap kemampuan berpikir kreatif. Hasil penelitian mengakibatkan guru mengembangkan curiosity dan media serta proses pembelajaran siswa untuk menumbuhkan kemamampuan berpikir kreatif mereka.

INTRODUCTION

People have information technology and innovation abilities in the industry 4.0 (Puncreobutr, 2016). *Education 4.0* encourages humans and technology to develop possible progress (Hussin, 2018). H*ard skills formed in Education 4.0 are problem solving, collaboration, critical, creative, productive, literacy, innovation, and communication* (Hussin, 2018; Puncreobutr, 2016; Rochmad et al., 2019). S*oft skills* formed in Education 4.0 are leadership, responsibility, and social (Hussin, 2018; Puncreobutr, 2016).

The mathematics is studied by paying attention to students' way of thinking (Rochmad et al., 2018). Creativity is the ability to provide innovative, new, original and meaningful responses from a situation, but the responses are not necessarily new to other individuals (Aljarrah, 2020; Bicer et al., 2020; Wahyudi et al., 2019). Creative thinking is thinking of giving some answers or a completion process; innovate and connect mathematics with other sciences or real circumstances; and create new ideas (Hadar & Tirosh, 2019; Saltis et al., 2019). The ability of mathematical creativity is the ability to provide multiple answers or processes to solve a problem of mathematical concepts and operations (Tubb et al., 2020). Creative thinking can be developed using problem solving (Ayllon et al., 2016). Mathematics creative thinking ability is the ability to solve mathematics problems with new thoughts and experiences. Torrance's assessment of creative thinking through problem solving has the following three parameters: fluency, flexibility, and novelty (Mulyono et al., 2020).

Trigonometry is a new and difficult material (Gerhana et al., 2017; Kamber & Takaci, 2018; Mensah, 2017). It is abstract. Students have not been able to connect concepts and principles whose are relevant to learn trigonometry (Yang & Sianturi, 2017). Students have difficulties to choose steps of problem solving. Solution steps are trigonometry comparisons, trigonometry inverse, equalizing denominators, algebraic operations, and factoring on trigonometry.

The results of 2015 PISA research at mathematics abilities show that Indonesia is ranked 64th of 72 countries. Indonesia has score 386 points of score 490 points (OECD, 2016). The results of 2015 PISA research at mathematics abilities show that Indonesia has 379 points of score 487 points. Indonesia is ranked 73rd of 79 countries (OECD, 2019). Mathematical literacy has positive influences in the amout of 46,5% on creative thinking ability (Fitrianawati, et al., 2020). Since literacy ability is less optimum, the creative thinking ability becomes less optimum, too. This is in accordance with research conducted by Isnaeni et al (2020) and Nurhayati & Wahyuni (2020) stating that the ability of creative thinking is not optimum.

Some students become less active during the learning process because they ask other smart and diligent students to complete their tasks. On the other hand, it is also found that there is also an individualistic student in a group. Based on the 2013 curriculum, mathematics learning process needs a long period of time due to the large amount of material to be taught. As a result, teachers try to complete the tasks based on the result and not on the process (Wahyudi et al, 2019). Trigonometry learning process focuses on memorizing (Fiallo & Gutierrez, 2017). This gives an influence on the student's creative thinking ability on mathematics materials, especially trigonometry.

In the learning process, there should be a high level of curiosity on creative thinking ability (Isnaeni et al, 2020). Since the development of information changes from time to time, students need to develop curiosity (Gorlewicz & Jayaram, 2019). Curiosity gives support students to learn (Goldspink & Engward, 2019). Many people can get information about unexpected, interesting, confusing, and new experiences (Kidd & Hayden, 2015; Silvia, 2017). One factor for students to understand a concept is curiosity (Mouromadhoni, Atun, & Nurohman, 2019). Jones states that creativity is formed through personality characteristics, the ability to think, mental process, attitude, as well as curiosity, adventurous feeling, bravery and thinking personality traits of an individual (Hu, Wu, & Shieh, 2016). Curiosity supports students' creativity to seek unsolvable new knowledge (Hagtvedt, et al, 2019). There is no correlation between curiosity and creativity based on the score. Meanwhile, curiosity has an indirectly positive relationship with creativity (mediation/ interview) (Schutte & Malouff, 2020). Investigation on the relationship between curiosity and creative thinking ability is conducted in this research.

Curiosity is an individual's personality in connecting new experiences with his/her abilities (Ainley, 2019; Kidd & Hayden, 2015). Curiosity on mathematics is a curiosity about mathematical truth and problem solving (Rahayu et al., 2019; Toptas, 2019). The personality to solve math problems and prove the truth with the knowledge possessed is curiosity. Curiosity is formed when students ask friends or teachers about the difficulties; and make hypotheses, explore, search, construct and investigate new knowledge (Ertando et al., 2019; Wade & Kidd, 2019). Curiosity indicators of mathematics learning are organic, social, and cognitive (Ainley, 2019).

Creative thinking ability develops mathematical creativity to solve problems in a new way (Wahyudi, et al., 2020). Creative thinking can be enhanced using problem solving (Ayllon, et al., 2016). Curiosity on mathematics is a curiosity about mathematical truth and problem solving (Rahayu et al., 2019; Toptas, 2019). Curiosity develops students' creativity to gain new knowledge (Hagtvedt, et al., 2019). Creative thinking ability is measured from fluency, flexibility, and novelty (Mulyono et al., 2020).

The student's condition means the student's cognitive and affective ability towards mathematical creative thinking ability and curiosity. Manipulation media in mathematics learning is used to develop high-level thinking ability (Hidayah, et al., 2021). Mathematics learning will be good if the learning is equipped with adequate media. One of the interactive media that can be used is the Student Worksheet and Student Assignment Sheet.

METHOD

Design

This research uses quantitative research with multivariate analysis design. It aims to find out whether the creative thinking ability and curiosity average of students is optimal or not, in turn, can determine the effect of curiosity on students' creative thinking ability (Queirós et al., 2017).

Instruments

This research instruments are a curiosity questionnaire and a creative thinking ability test. A curiosity questionnaire contains 74 statements. There are indicators of curiosity. Indicators of curiosity are organic, social, and cognitive. Organic indicator is the ability to explore knowledge. Social indicator is the ability to ask and search for all people and learning media. Cognitive indicator is the ability to connect results of exploration with results of asking and searching.

A creative thinking ability test contains 4 questions. There are indicators of creative thinking ability. indicators of creative thinking ability is fluency, flexibility, and novelty (Mulyono et al., 2020). Fluency is developing ideas. Flexibility is providing many kinds of ways and solutions. Novelty is creating new solutions. The material of a creative thinking ability test is trigonometry comparisons.

Participants

One of Semarang state high schools, academic year 2020/2021, is the place where this research was conducted. The research population in a row is all students of classes of X MIPA. The number of X MIPA classes is 1. Each class has 36 students. Purposive sampling is used to choose a research sample (Campbell et al., 2020). The research sample is X MIPA 3 class because X MIPA 3 has the creative thinking ability as same as every class.

Each class takes mathematics lessons in the even semester of the 2021 academic year. Mathematics is a compulsory subject in the 2013 curriculum. The creative thinking ability and curiosity help students understand mathematics. A creative thinking abiity is influenced by the teacher’s condition in preparing the Learning Implementation Plan.

Research Procedure

The research population is observed for two weeks. In the planning stage, the researcher and two lecturers make and discusse about a curiosity questionnaire, and a creative thinking ability test for two weeks. References of leading journals, a curiosity dan creative thinking ability indicator, and a preparation of questions and materials are prepared at this stage.

The implementation stage, this population is given a creative thinking ability test. The results of the creative thinking ability test are used to take a research sample. X MIPA 3 has the creative thinking ability as same as every class. This sample is given a curiosity questionnaire. Two lecturers observe the results of creative thinking ability test and curiosity questionnaires indirectly.

The evaluation stage, the results of the creative thinking ability test and curiosity questionnaire are discussed that they can solve math problems. The implementation and evaluation stages are carried out for 3 weeks.

Data collection

Multivariate studies are used to examine the differences in students' creative thinking ability in each class, determine the curiosity of X MIPA 3 students and determine the effect of the curiosity on the creative thinking ability. The dependent variable is the matematics creative thinking ability. The independent variable is students' curiosity.

The first test is the test of creative thinking ability. The test contains 3 description questions to assess each indicator of students' creative thinking ability (Mulyono et al., 2020). The first test is given to each class X MIPA. The second test is a curiosity questionnaire. The questionnaire contains 74 questions with a Likert scale to assess each student's curiosity indicators. A curiosity questionnaire is given to class X MIPA 3 after carrying out the first test.

The creative thinking ability test and curiosity questionnaire are tested for discriminatory power, level of difficulty, validity, and reliability. The data of the two tests are obtained then it is used to obtain the magnitude of the effect of the curiosity on the creative thinking ability.

Creative thinking ability test has test results of discriminatory power, level of difficulty, validity, and reliability. The discriminatory test result is .388 which shows a good criterion. The difficulty level test result is 55%. It is moderate criteria. The result of the validity of the first, second and third questions is .418, .722, and .8. The result of the reliability test is .39. The table correlation coefficient is .329. All questions are valid and reliable because they are more than .329.

The curiosity questionnaire has test results of discriminatory power, difficulty level, validity, and reliability. The discriminatory test result is .522 which shows a good criterion. The difficulty level test result is 69%. It is moderate criteria. In the 74 questions stated in the Curiosity Questionnaire, the correlation coefficient results are not displayed. The result of the reliability test is .366. The table correlation coefficient is .329. All questions are valid and reliable because they are more than .329.

Data Analysis

The quantitative analysis stages use two stages. The first stage, Testing Assumptions of Parametric statistics use the normality test, homogeneity test, linearity test, autocorrelation test, and heteroskedasticity test with 5% of significant levels.

The second stage is One Way ANOVA, the proportion test (one side z test), the average test (one side t test), and the regression analysis with 5% of significant levels. One way ANOVA is

Table 1. Result of Sig. from LSD on The Student's Creative Thinking Ability

Class	X M 1	X M 2	X M 3	X M 4	X M 5	X M 6	X M 7	X M 8	X M 9	X M 10
X M 1	-	.967	.492	.539	.967	.902	.910	.645	.015	.010
X M 2	.97	-	.519	.512	.935	.870	.878	.674	.017	.011
X M 3	.49	.519	-	.194	.467	.418	.424	.822	.080	.059
X M 4	.54	.512	.194	-	.566	.623	.616	.282	.002	.001
X M 5	.967	.935	.467	.566	-	.935	.943	.616	.014	.009
X M 6	.902	.870	.418	.623	.935	-	.992	.559	.011	.007
X M 7	.910	.878	.424	.616	.943	.992	-	.566	.011	.007
X M 8	.645	.674	.822	.282	.616	.559	.566	-	.049	.034
X M 9	.015	.017	.080	.002	.014	.011	.011	.049	-	.886
X M 10	.010	.011	.059	.001	.009	.007	.007	.034	.886	-

Note: M is MIPA

used to know mean differences in students' creative thinking ability in each class. The proportion test is used to know whether the percentage of students' creative thinking ability score more than equals 75 is more than 75%. The average test is used to know whether the students' creative thinking ability average is more than 75. The regression analysis is used to know that curiosity positively affects creative thinking ability (*see table 1*).

RESULTS AND DISCUSSION

Results

The results of the research at one of the state high schools in Semarang are creative thinking ability and curiosity results. Three questions were used in this research. The solution of the questions is analysed with a level of mathematical creative thinking ability (Siswono, 2011). The creative thinking ability test is carried out for 30 minutes on the ten classes of X MIPA. Test results can be observed in Table 2.

Table 2. Student's Creative Thinking Ability Description

Class	N	Mean
X MIPA 1	36	68.0000
X MIPA 2	36	68.1111
X MIPA 3	36	69.8611
X MIPA 4	36	66.3333
X MIPA 5	36	67.8889
X MIPA 6	36	67.6667
X MIPA 7	36	67.6944
X MIPA 8	36	69.2500
X MIPA 9	36	74.6111
X MIPA 10	36	75.0000

Normality test uses One Sample Kolmogorov Smirnov Test. The result of the significant value of normality test on creative thinking ability of the ten classes of X MIPA in a row is .601, .63, .150, .644, .724, .789, .088, .642, .271, and .131. Data on each student's creative thinking ability has a normal distribution, because asymp. Sig (2-tailed) more than .05.

Homogeneity test of creative thinking ability uses One Way ANOVA. The result of students creative thinking ability using sig. of test of homogeneity of variances is .966. Data variance of students' creative thinking ability is homogeneous because sig is more than .05.

Average test of creative thinking ability uses One Way ANOVA. The result of sig one way anova is .011. There is an average difference in creative thinking ability from ten classes, because sig is less than .05. Advanced Test result uses tukey HSD and LSD from Post Hoc. Mean result of creative thinking ability advanced test can be observed in Table 2 and 3.

Table 3 Result of sig. from Tukey HSD on the student's creative thinking ability

Class	Subset for alpha = .05	
	1	2
X MIPA 4	66.3333	
X MIPA 6	67.6667	67.6667
X MIPA 7	67.6944	67.6944
X MIPA 5	67.8889	67.8889
X MIPA 1	68.0000	68.0000
X MIPA 2	68.1111	68.1111
X MIPA 8	69.2500	69.2500
X MIPA 3	69.8611	69.8611
X MIPA 9	74.6111	74.6111
X MIPA 10		75.0000
Sig.	.072	.174

Because sig. > .05 so that the results of some student's creative thinking ability are similar. Based on Table 1 and 2, the conclusions are as follows: the creative thinking ability average on the ten classes of X MIPA are similar. Each pair of eight classes of X MIPA has similar average on creative thinking ability. They are X MIPA 1, 2, 3, 4, 5, 6, 7, and 8. Each pair of three classesof X MIPA has similar average on creative thinking ability. They are X MIPA 3, 9, and 1.

Because data on each student's creative thinking ability has a normal distribution, the proportion test uses the one sample proportion test and the mean test use the one sample average test. A z arithmetic score and z table of the proportion test is -6.1586 and 1.645. Because -6.1586 < 1.645, the percentage of students' creative thinking ability score more than equals 75 is less than 75%. A t arithmetic score and t table of mean test is -2.67207 and 1.6935. Because -2.67207 < 1.6935, the students' creative thinking ability average is less than 75. Because the percentage of students' creative thinking ability score more than equals 75 is less than 75% and the students' creative thinking ability average is less than 75, students' creative thinking ability mean is not optimal.

Seventy four questions were used in the research. The curiosity questionnaire is carried out for 60 minutes on X MIPA 3. The average questionnaire result of curiosity character on X MIPA 3 is 169.361 from 296. The standard deviation result of curiosity character on X MIPA 3 is 11.88.

The significant value of Normality test result is obtained .607 > .05. It shows that Data on student's curiosity has a normal distribution. Because that, the proportion test uses the one sample proportion test and the average test use the one sample average test. A z arithmetic score and z table of the proportion test is -4.333 and 1.645. Because -4.333 < 1.645, the percentage of students' curiosity score more than equals 192.4 is less than 75%. A t arithmetic score and t table of mean test is -11.63 and 1.6935. Because -11.63 < 1.6935, the students' average curiosity is less than 192.4. Because the percentage of students' curiosity score more than equals 192.4 is less than 75% and the students' average curiosity is less than 192.4, students' average curiosity ability is not optimal.

Normality test of curiosity on the creative thinking ability uses Kolmogorov-Smirnov test. The normality test result uses normally distributed data. Linearity test uses Lagrange Multiplier test. The result of linearity test is obtained chi square arithmetic = 32.688 < 49.765 = chi square tabel. It shows that the regression equation is linear. Autocorrelation test uses Durbin Watson test because 2.968 = 4 – dW > dW = 1.531 > 1.525 = dU > 1.411 = dL, no autocorrelation occured. Heteroskedasticity test uses Glejser test because sig = .303 > .05, regression model doesn't have Heteroskedasticity.

The linear regression is used. The significant value of the linear regression analysis result is .00 < .05 so that there is positive influences of curiosity on the creative thinking ability in the amout of 3.12%.

Discussion

At most schools, Teachers have students' problems in their learning. Obvious problems can foster new ideas. Students' problems are at psychological, cognitive, and environmental conditions. Thus, environmental conditions support psychological and cognitive students. Therefore, this study found conditions of students' creative thinking ability and curiosity and the influence of curiosity to creative thinking ability at X Classes. The research, in which the material was trigonometry, was conducted in one of public high school in Semarang.

The results of creative thinking ability test have three groups at X MIPA 3 class. The first group has two students. Two students don't have creative thinking ability indicators. The second group has 29 students. 29 students have fluency indicator, but don't have flexibility and novelty indicators. The third group has 5 students. Five students have fluency and novelty indicators, but don't have flexibility indicator. The percentage of students' creative thinking ability score more than equals 75 is less than 75% and the students' creative thinking ability average is less than 75. Thus, students' creative thinking ability average of X MIPA 3 Class is not optimal. The creative thinking ability average is not optimal (Isnani et al., 2020).

Learning media has supported students to construct their knowledge. Students are guided on prerequisite materials. They are used to solve problems, but few students cannot use some prerequisite material. Learning media help students find information and conduct discussions (Wang et al., 2020). Therefore, a lot of students have fluency indicator.

Because the large number of learning materials is not in accordance with the learning time, the teacher sometimes uses lecture methods, or the teacher does not explain some of the materials in the Student Worksheet. Teachers only think about the results of completing materials instead of paying attention to the process of solving them (Wahyudi et al., 2019). Trigonometry learning focuses at memorization (Fiallo & Gutiérrez, 2017). Students' activities are low, students do not scientific activities (Yaniawati et al., 2020). Students do not have the opportunity and freedom to find new ideas in learning. Students are not trained to solve new problems. Students are satisfied to get one solution. Therefore, students don't have flexibility and novelty indicators.

Creativity provides innovations in problem solving (Carbonell-Carrera et al., 2019). Students have known creative thinking ability, but students don't practice it. The Student Worksheet in the Learning Implementation Plan (RPP) has Discovery Learning model, scientific approaches, and lecture method, but the worksheet has not focused on students' creative thinking ability. Two factors influencing students' problem solving ability are the thinking and studying processes in cognitive field. (Mefoh, et al., 2017; Salido, et al., 2020).

Teachers have to know students' characteristics to prepare learning media (Kintu et al., 2017). Manipulative learning media enhances creative thinking ability in accordance ith the student's condition (Sugiman et al., 2020). Creativity can be increased through social media. Social media is means of sharing and gathering information in learning (Berestova et al., 2021). The worksheet must contain developments of creative thinking ability.

Students potential is developed by their positive affective (Yaniawati et al., 2020). Because of the development of information and technology, curiosity is needed by students (Gorlewicz & Jayaram, 2019). It encourages students to know about information and problem solving in the future. Curiosity encourages students to study (Goldspink & Engward, 2019).

The results of curiosity questionnaire in X MIPA 3 have four groups. The first group does not have any curiosity indicator. The second group has an organic indicator, while the third group has both organic and social indicators. Finally, the fourth group has organic, social, as well as cognitive indicators. The percentage of students' curiosity score more than equals 192.4 is less than 75% and the students' average curiosity is less than 192.4. Students' average curiosity is not optimal.

Curiosity is developed by environmental conditions (Lamnina & Chase, 2019). A few information encourages individuals to want information, so individuals develop curiosity. Curiosity is formed when students ask to others and make hypotheses, explore, search, construct, and investigate new knowledge (Ertando et al., 2019; Wade & Kidd, 2019). The worksheet has a monotonous appearance. If teachers pay attention to learning media based games, curiosity can be formed. Digital games increase students' motivation and engagement in learning (Behnamnia et al., 2020).

The linear regression analysis result is a positive influence of curiosity on creative thinking ability, which is 3.12%. Curiosity is a positive factor to encourage students' problem solving (Leo, et al, 2019). Creative thinking will grow if students are encouraged to have curiosity. Curiosity encourages students' creativity to seek new, unresolved knowledge (Hagtvedt et al., 2019). The students must grow curiosity in learning so that students have a desire to learn and develop creative thinking ability.

Students give s creative behavior if students have curiosity. Students connect ideas and information. Information is obtained because students search and explore new problems (Gross et al., 2020). Curiosity helps students to start creative activities, so they get solutions of problems.

Two students who don't have curiosity indicators don't have creative thinking ability indicators. Two students do not pay attention and do not focus on learning, because two students weighing problem-solving on smarter students in their groups. They can't apply the prerequisite of trigonometry comparisons. They have some trouble, but they don't ask questions to someone. Smart students have an individual nature to their group members. However, students need other students in learning (Hussin, 2018). Students do not want to explore information if students do not develop their abilities.

29 students who have organic indicator or organic and social indicators have fluency indicator, but don't have flexibility and novelty indicators. Students are active in learning. Students can solve problems. Problems have been solved in learning. Students follow the guidance. They imitate problem solutions and develop their knowledge. Students only use learning materials from the teacher. Learning materials has systematic stages but does not develop students' creative thinking ability. Learning has to have high curiosity to make creative thinking ability (Isnani et al., 2020).

Five students who have organic, social, and cognitive indicators have fluency and novelty indicators. They can use prerequisite materials to solve problems. The lack of learning time and competition in each group causes students to have only a narrow view of solving problems. Some students who succeed in the test are students who use tutoring services. Curiosity helps students to solve, find out, and seek everything (Rahmantiwi & Rosnawati, 2018). Curiosity is a desire to find out infomation, improve competency and memory (Gruber & Ranganath, 2019).

Curiosity positively affects creative thinking ability. Because the character of the students' curiosity is not optimal, students' mathematical creative thinking ability is not optimal. Teachers must make learning multimedia. Learning media develops curiosity and creative thinking.

Implication

Curiosity must be considered to develop the creative thinking ability. The creative thinking ability is also very important to train students. Students are trained to solve problems in the future. Research implications are the discovery of creative thinking ability's descriptions or patterns on curiosity and learning models and multimedia. There are many kinds of learning models and multimedia to develop creative thinking ability. There are other studies on the impact of the implementation of learning models to develop creative thinking ability. Creative thinking ability can improve using math adventure educational game (Kartika et al., 2019). The RBL method with Scientific Approach using e- Learning media improve creative thinking ability (Yaniawati et al., 2020). Digital educational games make motivation, creativity and skill children (Behnamnia et al., 2020).

Limitation

Future research may address research limitations. Limitations are the results of a research. Results contain only the influence of curiosity on creative thinking ability at the learning. The learning used Discovery Learning Model and a simple learning media. Discovery Learning Model has flaws. Learning process takes a long time. The research uses quantitative methods with multivariate analysis design. A study suggests using different methods and designs. They analyze the effect of curiosity of creative thinking ability. Because the percentage of positive influences on curiosity of creative thinking ability is 3.12%, there are positive influences of some character education on creative thinking ability. The research suggests that teacher must see some character education on creative thinking ability.

CONCLUSSION

The learning time doesn't sufficient to convey material, teacher concerned results than process. Students can't apply the prerequisite material to solve new problems. The learning media does not develop students' creative thinking ability. The percentage of students with creative thinking ability score more than 75 is less than 75% and the students' creative thinking ability average is less than 75. These indicate that students' creative thinking ability average is not optimal.

Learning media has a monotonous appearance, so that students' curiosity can't be formed. The percentage of students with creative thinking ability score more than 75 is less than 75% and the students' creative thinking ability average is less than 75. These show that students' creative thinking ability average is not optimal. The percentage of curiosity positive influences on creative thinking ability is 3.12%. Organic, social, and cognitive indicators of the curiosity have positive influences on fluency and novelty indicators of the creative thinking ability.

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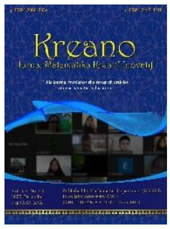
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 267-279



Development of Animated Video-based Mathematics Learning on The Three-dimensional Material of Class XII SMA to Improve Mathematical Literacy

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Abstract

This article discusses the development of animation-based learning videos on three-dimensional materials to improve mathematical literacy. This development research uses the Plomp model, that is, preliminary research, development or prototyping, and assessment phase. The results of the learning video in this development are viewed under three aspects, namely validity, practicality, and effectiveness, involving students of SMA Negeri 3 Pekanbaru as research subjects. The animated video-based learning media was declared very valid with a result of 73, very practical with a result of 56, and effective in improving mathematical literacy. This states that animation-based video learning media is good and worthy of being used as a mathematics learning media to improve mathematical literacy.

Keywords: Learning media; Adobe after effect; Mathematical literacy

Information of Article	
Subject classification	*97U80 Audiovisual media (aspects of mathematics education)*
Submitted	*18 October 2022*
Review Start	*23 October 2022*
Initial Review Finish	*29 October 2022*
Round 1 Finish	*5 January 2023*
Round 2 Finish	*23 May 2023*
Round 3 Finish	*9 July 2023*
Accepted	*9 July 2023*
Published	*19 November 2023*
Similarity Check	*11%*

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Abstrak

Artikel ini membahas pengembangan video pembelajaran berbasis animasi pada materi tiga dimensi untuk meningkatkan literasi matematika. Penelitian pengembangan ini menggunakan model Plom, yaitu tahap penelitian pendahuluan, pengembangan atau prototyping, dan penilaian. Hasil video pembelajaran dalam pengembangan ini dilihat dalam tiga aspek, yaitu validitas, kepraktisan, dan efektivitas, dengan melibatkan siswa SMA Negeri 3 Pekanbaru sebagai subjek penelitian. Media pembelajaran animasi berbasis video dinyatakan sangat valid dengan hasil 73, sangat praktis dengan hasil 56, dan efektif dalam meningkatkan literasi matematika. Hal ini menyatakan bahwa media pembelajaran video berbasis animasi baik dan layak digunakan sebagai media pembelajaran matematika untuk meningkatkan literasi matematika.

INTRODUCTION

One of the movements emphasized by the minister of education for students today is literacy skills. Literacy skills are currently indispensable to supporting the achievement of educational goals (Muzaki & Masjudin, 2019). As for the literacy needed by humans in the field of education, one of them is mathematical literacy.

Mathematical literacy is the ability of an individual to formulate, use and interpret mathematics in various contexts, including the ability to perform mathematical reasoning and use concepts, procedures, and facts, as a tool to describe, explain and predict a phenomenon or event. Good mathematical literacy skills will make it easier for students to solve mathematical problems in their daily lives. Mathematical literacy also requires students to be able to communicate and explain the phenomena they face with mathematical concepts (Fatwa et al., 2019; Khoirudin et al., 2017; Mansur, 2018; Masmufah & Afriansyah, 2021; Muzaki & Masjudin, 2019, Maryati et al., 2021).

PISA (*The Programme for International Student Assessment)* is a program initiated by the OECD *(Organization for Economic Cooperation and Development)* that focus on literacy which emphasizes the skills and competencies of students obtained from school and can be used in everyday life (Johar, 2012). PISA conducts a triennial assessment to determine student literacy in reading, science, and mathematics (Syawahid & Putrawangsa, 2017). This program pays more attention to what students do than what they learn in school, especially in having mathematical literacy skills.

But in fact, based on the PISA (The Programme for International Student Assessment) assessment, shows that the mathematics literacy score in Indonesia is still below the mathematics literacy score of other countries. Students in Indonesia ranked 39th out of 40 sample countries in 2003, 38th out of 41 countries in 2006, 61st out of 65 countries in 2009, and 62nd out of 70 countries in 2015 with a score of 403 out of an OECD average score of 493. This is in line with the fact that there are still many students in Indonesia who feel that mathematics is a difficult lesson. As corroborated by the findings (Djidu & Retnawati, 2018),(Zana et al., 2022) that students in Indonesia still have difficulty in mastering higher order thinking skills (HOTS). In fact, mathematics learning is one of the subjects that have an important role in the needs of students' lives (Afifah et al., 2018). Therefore, the teacher must be able to apply methods, strategies, or possible ways so that students can master mathematics well (Habibi & Suparman, 2020; Masfufah & Afriansyah, 2021; Muzaki & Masjudin, 2019).

One of the efforts to improve students' mathematical literacy is the existence of learning media. Learning media play an important role in conveying learning between teachers and students. Learning media is a useful tool to convey information between teachers and students, and support student learning success (Abidin, 2017; Aghni, 2017; Hartanto, 2016; Yanto, 2018). Learning media can also help teach abstract concepts so that they are more easily accepted by students (Hasiru et al., 2021; Maharani et al., 2018). Especially in mathematics subjects, learning media is very important so that it can develop imagination and can improve mathematical literacy as well.

One of the mathematical materials that need to be used in learning media is the third dimension. The difficulties or problems that arise in learning three-dimensional material include (1) Understanding the theory and drawing of three-dimensional materials require a fairly high level of abstraction; (2) The concepts given to students have a high degree of difficulty because they must be related to other concepts such as trigonometry and triangle; (3) Teaching methods that still use the lecture method; and (4) Limited learning media, both in terms of quantity and quality. The use of learning media in three-dimensional material is expected to provoke and develop students' imagination in the material presented.

Therefore, the learning media that is suitable for use of three-dimensional material is animated video-based learning media. One of the software that can be used to create animated video-based learning media is Adobe After Effect. Adobe After Effect is a software that creates animation works and visual effects that are used for multimedia presentations and various advertising animations, one of which is tutoring animation (Azhar et al., 2021; Yenti, 2020, Fauzi & Chano, 2022). The Adobe after effects application serves to create animated works with real visual effects such as melted solids, snowy atmospheres, or the addition of fire effects to a movie.

Several studies related to animated video-based learning media on three-dimensional material to improve mathematics literacy was carried out by (Handoko, 2017; Masfufah & Afriansyah, 2021; Tamu et al., 2020; Yenti, 2020). Based on the problems found and research that has been done previously, learning media in the form of animation-based videos on three-dimensional materials is needed to improve mathematical literacy. The difference between this study and previous research is the use of technology in making animated video-based learning media using Adobe After Effect. By using the effects available in adobe after effect, animated video-based learning media is expected to cause and increase the imagination of students so that students' mathematical literacy can increase.

METHODS

This type of research is development or Research and Development (R&D). This development research aims to produce products. The development model used in this study is the Plomp model. There are three stages used in the Plomp model, namely preliminary research, development or prototyping, and the assessment phase. The development process forms a cycle, where the development cycle will stop if the product being developed is suitable for use, that is, it meets valid, practical, and effective criteria. Schematically presented in Figure 1.

As for each stage of the activities carried out at each stage of development are described as follows. The first stage is Preliminary research. In this stage, the problems analyzed were problems of learning mathematics, problems of learning by teachers, the media used, material that was still problematic, reviewing the literature and reviewing relevant supporting research results. The results of this preliminary study serve as the basic concept for further development of the prototype design.

After the preliminary research has been carried out, the next stage of development is compiling the initial prototype. This stage aims to prepare prototypes of learning media and supporting devices. To make it easier for researchers in the development process, it is necessary for the researcher to make a work plan and estimate the time needed at each stage of development and testing on respondents. At this stage the researcher designed a media prototype, learning tools (syllabus, lesson plans, validation instruments, and evaluation in the form of math literacy questions). The results of the initial prototype development were validated by material experts and media experts. After validating the expert, the researcher

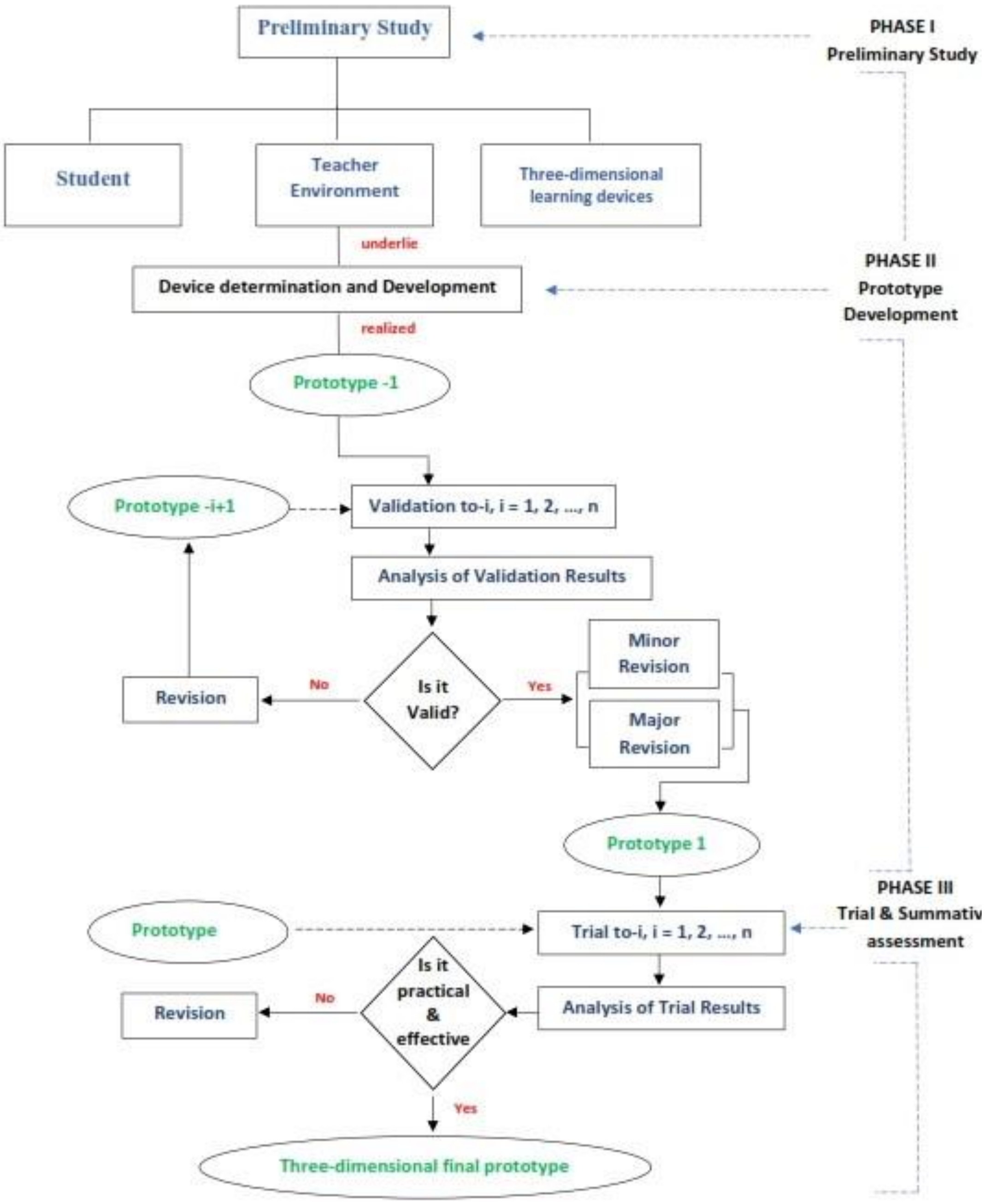

Figure 1. Ploomp Development Process Stage

revised it until the prototype was declared feasible for testing.

Furthermore, the results of the initial prototype that had been developed were declared feasible, then it was continued with field trials. In this case the researchers conducted trials on students of SMA N 3 Pekanbaru. The research location was conducted at SMA Negeri 3 Pekanbaru with the subject of research of as many as 36 students of class XII MIPA 1. The data obtained is quantitative data. Data collection in this study used media expert instruments, response questionnaires, and student learning outcome sheets. Media expert instruments to measure how valid animated videos are produced, response questionnaires to measure the practicality of learning media, and student learning outcomes sheets (pre-test & post-test) to measure effectiveness in improving students' mathematical literacy.

Data analysis for validity instrument by calculating the average of scores that have been assessed by experts is converted into quantitative criteria referring to Table 1. Learning media are declared valid if the average score of experts is in a valid statement.

Table 1. Validity Criteria

Interval	Validity Criteria
$X \geq 65$	Very Valid
$65 > X \geq 50$	Valid
$50 > X \geq 35$	Less Valid
$X < 35$	Very Invalid

Description:
X = average actual score

Furthermore, data analysis for practicality is obtained through the assessment of response questionnaires by students. The data obtained are converted into quantitative criteria referring to Table 2. Learning media are declared practical if the assessment that has been converted is in a practical description.

Table 2. Practicality Criteria

Interval	Practical Criteria
$X \geq 48.75$	Very Practical
$48.75 > X \geq 37.5$	Practical
$37.5 > X \geq 26.25$	Less Practical
$X < 26.25$	Very Impractical

Description:
X = average actual score

Finally, data analysis for the effects of learning media aimed at improving students' mathematical literacy. Data were obtained from the comparison of values (pretest & posttest) with paired sample t-test. If a Sig. (2-tailed) value is obtained < 0.05, the learning media is declared effective for improving mathematical literacy, and vice versa.

RESULTS AND DISCUSSION

The media produced in this development is an animated video-based learning media on three-dimensional material. The results of the development of animasi-based video learning media on three-dimensional material are as follows.

Preliminary Research

This research first begins with conducting a needs analysis. At this stage, an analysis of learning tools at SMA Negeri 3 Pekanbaru was carried out. To find out about the problems that exist in school, interviews are first conducted with mathematics teachers and students who have taken three-dimensional lessons. After the interview, it was found that the mathematics teacher had used learning media, but he felt that it was less effective when using the media because of the large number of students who were remedial during the daily test of the three-dimensional material. This is reinforced by the answers of the students who stated that they find it difficult to imagine three-dimensional material because of the learning media they do not fully own and are very limited.

Furthermore, an examination of the learning devices and media used by mathematics teachers was carried out. Based on the analysis carried out, it was obtained that learning activities on three-dimensional material are quite good with rough learning media. However, based on the learning media used by mathematics teachers, it is also very limited, it is also difficult to make students' imaginations formed which causes mathematical literacy in three-dimensional materials to also be lacking. This problem is justified by research that has been carried out before so that students think that dimension three is one of the mathematical materials that is quite difficult (Gustiadi et al., 2021) ; (Noto et al., 2019).

Based on the analysis that has been carried out, teachers and students need effective learning media that can improve students' mathematical literacy. In addition, it requires learning media that are easy to obtain and use for three-dimensional materials. Based on this analysis, it can be concluded that there is a need for animated video-based learning media to support learning activities on three-dimensional material. This has also been supported by previous research studies that animated video-based learning media is an effective medium and easy to obtain by teachers and students (G. P. P. Hapsari & Zulherman, 2021).

Furthermore, this stage is carried out by analyzing the study of material, namely dimension three. In this activity, learning outcomes will be detailed in the three-dimensional material by referring to the curriculum used. Then the material is adjusted to the learning outcomes in the learning device design (RPP) which will be used to design material on animated video-based learning media in the design phase and prototype development.

Development or Prototyping

This phase begins with determining learning objectives based on learning outcomes and referring to material adapted to the lesson plan, determining the test subject and the design of the learning media to be produced. Referring to the RPP, then an animated video-based learning media design is designed which is divided into 3 sub-materials, namely the distance between points, the distance from the point to line, and the distance from the point to the plane. Each video-based learning media is accompanied by a learning opening, the material to be delivered, and the closing. The result of the design is in the form of an animated video to bridge and facilitate the learning of the dimensions of the three classes in high school. The results at this stage are referred as prototype 1 which will be validated by the media expert validators.

Validation of animation-based video is carried at this stage. Animation video validity data were obtained from two validators to provide an assessment of the feasibility and quality of the video from the material, media, and language aspects with a total of 15 statements. Expert validators are lecturers from Riau Islamic University and practitioners from Telkom University. When the validation process was carried out on prototype 1 carried out by lecturers and practitioners, there were several inputs and comments, namely asking for the replacement of characters (who did not wear hijab to wear hijab) contained in the opening of the animated video from the first sub-material, namely the distance between points. Next, the font used at the opening of the animated video from the first sub-material, namely Comic Sans MS, was changed to Eras Demi ETC, because the previous font was considered more suitable for elementary or junior high school students, not in accordance with the target students, namely high school students. This is one of the indicators of the improvement process from the initial design to adjust the level of students' development. As the results of previous research by Indriyani (2019); Ulfa & Suripah (2021) which corroborate the author's opinion that, the development of learning media must pay attention to the level of cognitive development and the stages of students' development academically.

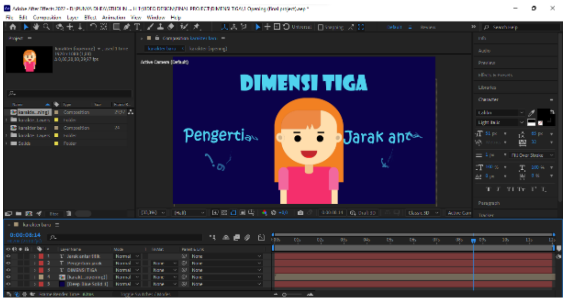

Figure 2. (Prototype 1)
Opening Character of The Distance Between Points on Prototype 1 And Using The Comic Sans MS font

Figure 3. (Prototype 2)
Opening Character of The Distance Between Points on Prototype 2 And Using Eras For ETC Fonts

The last part is design changes such as font colors and backgrounds that are tailored to the needs of the animation video. The font and background colors are not suitable because there are too many colors that will make students who watch them become unfocused with the content of the animated video. After receiving and making improvements to the revised animated video, improvements to prototype 1 that have been developed can be referred to as prototype 2.

Furthermore, prototype 2 is shown back to lecturers and practitioners. After prototype 2 was watched and viewed in its entirety, validators had enough of the animated video and assessed the video through filling out a 15-item video feasibility and quality assessment. So that the success of prototype 2 produced after being given input and suggestions at the validation stage can be declared valid. In the validation process carried out 2 times, the activities carried out are providing product input by validators and filling out validation questionnaires. Validation activities will start on June 21, 2022, and end on July 30, 2022. The results of the validation assessment from the two experts are 72 with very valid criteria. The overall results can be seen in Table 3.

Table 3. Validation results of animation-based video learning media

Validators	Actual Total Score	Criteria
Validators 1	67	Very Valid
Validators 2	77	Very Valid
Combined Validators	72	Very Valid

The results of the assessment by the validators in Table 3 show that the resulting product has very valid criteria. So that the animated video-based learning media created and developed has met the validity. Overall, the improved results of prototype 1 developed are referred to as prototype 2. The existence of prototype 2 then the validation process also ends at this stage. The end of the validation process at this stage is based on the results of revisions, inputs, and suggestions at the validation stage qualitatively. Likewise, based on the results in Table 4, which are stated to be very quantitatively valid. So that prototype 2 is ready to be tested in the Assessment phase.

Assessment Phase

Furthermore, at the assessment stage, a trial will be carried out on prototype 2 to find out the practicality and effectiveness of animated video-based learning media. In this assessment phase, there are two stages of trials, namely limited trials, and extensive trials. First, a limited trial was carried out by providing animated video-based learning for 10 students of class XII MIPA 1 on August 9, 2022. The purpose of the limited trial to 10 students is to see the practicality of learning media developed in a limited scope through a response questionnaire that will be filled in. In the limited trial, 10 students were allowed to watch three animation-based learning videos.

Figure 4. Students Watch Animation-Based Learning Videos

After the 10 students watched the animation-based learning video, they were given a response questionnaire to assess the animated video and asked to respond. So that student response data to animated video-based learning media is processed and can be presented in Table 4 below.

Table 4. Student Response to Animated Video-Based Learning Media

Respondents	Actual Score	Criteria
Student 1	60	Very Practical
Student 2	48	Practical
Student 3	58	Very Practical
Student 4	60	Very Practical
Student 5	45	Very Practical
Student 6	60	Very Practical
Student 7	58	Very Practical
Student 8	60	Very Practical
Student 9	56	Very Practical
Student 10	59	Very Practical
Total	564	Very Practical
Average	56.4	Very Practical

Based on Table 4, eight out of ten students give very practical assessments, and the other two people give assessments with practical criteria. Overall, out of ten 10 students obtained an average of 56.4 which can be concluded that the video-based learning media developed has met practicality with the criteria of "Very Practical". This is in line with previous research (Mandalitasari & Muthmainnah, 2022; Reinita, 2022, Wijayanti & Utami, 2022) that learning media using Adobe After Effect can meet practical criteria. So that previous research refining prototype 2 can be said to have met valid and practical criteria.

Furthermore, prototype 2 was distributed by continuing to widely trial to 35 students of XII MIPA 1 to find out the effectiveness of the products developed to improve mathematical literacy. The activity was carried out on August 16, 23, and 30, 2022. Before prototype 2 is given to all students, students are first instructed to do a pre-test regarding three three-dimensional sub-materials, namely the distance between points, the distance from a point to line, and the distance from the point to plane with each sub-material having 1 question item. After all, students have done the pre-test, then given prototype 2 to the students and given time to watch animation-based learning videos on their respective students' smartphones. They can use animated video-based learning media independently and do not feel difficult in terms of numbers because they have their own smartphones and can watch them repeatedly. After all the students finished watching the animation-based learning video, they were instructed to go back to do a post-test on the three sub-materials they had watched. Thus, the results of the pre-test and post-test answer sheets of all students are processed using SPSS and presented in Table 5.

Table 5. Pre-test and Post-test Answer Sheet Results on Animation-Based Learning Videos

	Mean	Sig. (2-tailed)
Pre-test	49.43	.000
Post-test	83.86	

Based on the results of Table 5, the data obtained were analyzed using the SPSS version 25 program obtained through a paired sample t-test. The value of Sig. (2-tailed) is 0.00 which is known if 0.00 < 0.05 then there is a significant difference between pre-test and post-test learning outcomes, so it can be concluded that animated video-based learning media on the material of the third dimension of class XII to improve mathematical literacy is declared effective. In other words, there is an increase in students' mathematical literacy after using animated video-based learning media. Then prototype 2 has met the criteria of valid, practical, and effective. Therefore, the products that have been produced in this development research can be used by teachers and students in teaching and learning activities in the classroom. In addition, students become easier and can have their own learning media.

Animation-based learning media that has met valid criteria with a score of 73, practically with a score of 56, and has been declared effective provides implications, namely that it can be used by teachers in the process of teaching and learning activities in the classroom for material to build curved side rooms. This learning medium can also be owned by all students, and they will not feel short of learning tools because they can have each of them. In addition, this learning media are also easy to obtain and can be seen repeatedly anywhere and anytime, which can make students' mathematical literacy increase and can make students' imaginations develop. In the long term, students are expected to have their own interest in learning mathematics. As a result, students realized that learning mathematics was no longer considered a difficult and rigid subject that dealt with numbers and numbers alone. But on the contrary, mathematics is one of the memorable subjects and can also be learned through media and applications as a group of other subjects that are not only struggling in books and struggling with formulas.

Figures 4 & 5. Animation-Based Learning Video Results

The results of the research that have been described according to the stages of Plomp development and a thorough discussion is carried out as follows. At the preliminary research stage, an analysis was carried out related to learning tools at SMA Negeri 3 Pekanbaru. Based on interviews with mathematics teachers and class XII students that learning media have been used, but it is not considered effective, students find it difficult to imagine three-dimensional material because of the limited learning media provided by the teacher. This is because three-dimensional material requires high imagination to make students' mathematical literacy at dimension three low. This is reinforced by the statement by Kusumawardani dkk (2018) and Mandailina dkk (2016) which states that the lack of media learning leads to low students' mathematical literacy which requires high imagination on three-dimensional material. Therefore, learning media are needed to facilitate three-dimensional material learning activities for all students that are effective and can increase imagination three. This became the basis for creating and developing animation-based learning videos on three-dimensional material to improve students' mathematical literation.

In the development or prototyping stage, before designing the learning media, three sub-material sub-materials are analyzed. This stage will produce animation-based video-based learning media that will facilitate teachers and students in teaching and learning activities for three-dimensional material. The draft results of this stage are called prototype 1. Furthermore, prototype 1 is validated by 2 validators both from the aspects of the material, media, and language. Validation activities were carried out 2 times starting on June 21, 2022, and ending on July 30, 2022. Based on the validation results of the learning video developed, it meets the criteria of "Very Valid" with a score of 72. There are several improvements, namely the change of characters who do not wear a hijab to a hijab, then the Comic Sans MS font to Eras Demi ETC, as well as changing the color of the font and background that is too colorful and is considered not fit for high school students. After revisions to the video-based learning media, improvements have been made to change prototype 1 to prototype 2. In the future, the product that is developed is referred to as prototype 2.

After prototype 2 was declared valid, it was continued with the assessment stage, which was to conduct a limited trial by 10 students to test the practicality by filling out a response questionnaire to students. Students watch animation-based learning videos. After students finish watching the animation-based learning video, students are instructed to fill out a response questionnaire. The results of the response questionnaire showed that animation-based learning videos were considered practical with the criteria of "Very Practical" with a score of 56.4. After being declared practical prototype 2, the animation-based learning video is ready to be widely tested involving 35 class XII students.

Prototype 2 was then widely piloted to test the effectiveness of learning videos to improve students' mathematical literacy on three-dimensional materials. Before prototype 2 is deployed, students are instructed to do a pre-test of three questions with three sub-materials, namely the distance between points, the distance from the point to the line, and the distance from the point to the plane. After doing the pre-test students are asked to watch prototype 2 or animation-based learning videos through their respective smartphones. After watching the animation-based learning video, students were asked to continue by doing a post-test of three questions. The results were obtained through the analysis of SPSS version 25 with a paired sample t-test which stated that the value of Sig. (2-tailed) is 0.00 and if $0.00 < 0.05$ then there is a significant difference between pre-test and post-test learning outcomes. So, it can be concluded that animated video-based learning media on the three-dimensional material of class XII to improve mathematical literacy is declared effective. Or in other words, animated video-based learning media is declared effective because of students' increased mathematical literacy through watching animation-based learning media. In addition, students seem more enthusiastic and motivated to follow the lesson (Suripah & Susanti, 2022; A. S. Hapsari & Hanif, 2019). The implication of the results of developing animation-based learning videos is that they can be used by mathematics lesson teachers to facilitate teaching and learning activities (Fatchurahman et al., 2022, Cao et al., 2021). In addition, students can easily use animation-based learning videos through their respective smartphones and not feel less facility than before. Furthermore, students are also expected to continue to improve their mathematical literacy skills only through problems in the classroom, but also through media-based mathematics learning.

Especially in this era full of technological integration today. Students are not only required to be able to master mathematics. But more than that, by mastering mathematical literacy, students can connect the basic concepts to reasoning and solving everyday contextual problems (Hayati & Kamid, 2019), (Yang et al., 2020).

Limitation

Students' expectations of the results of media development are not yet interactive. Students can only watch material explanations via video, and students cannot use the media interactively for both the learning process and practice questions.

Implication

The impact of the results of this study is directly related to the integration of technology in pedagogical content knowledge. This is in line with the existence of learning objectives in the independent curriculum which is currently a trending topic. Of course, the development of learning media will help the learning process be more flexible and not monotonous.

CONCLUSION

The results of the study showed that animasi-based video learning media on three-dimensional material that had been developed obtained the "Very Valid" criteria with a score of 72 based on assessments and comments from media expert validities at the design stage as well as prototype development. In the assessment stage, a limited trial was carried out by involving 10 students of class XII MIPA 1 SMA Negeri 3 Pekanbaru. The results of a limited trial showed that the development of animation-based video learning media had met the "Very Practical" criteria with a score of 56.4, of which 10 students filled out the response questionnaire. In addition, a widespread trial was carried out involving 35 students of class XII MI-PA 1 SMA Negeri 3 Pekanbaru. The results of the trial widely obtained "Effective" results through paired sample t-test with 36 grade 12 MIPA 1 students who worked on the pretest and posttest, the results showed that the Sig. (2-tailed) the score of 0.00 < 0.05 which means that learning animation-based video on the third dimension material of class XII to improve mathematical literacy was declared effective. This also indicates that one of the problems faced by students related to mathematical literacy can be used alternative Video Animation-Based Mathematical Learning Media Using Adobe After Effects.

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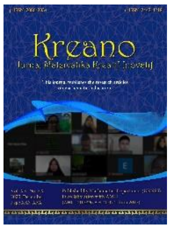
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 280-292



Identification of Representation Ability in the Topic of Space Analytical Geometry for Student in Higher Education

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Abstract

The objective of this research is to expose the representation skills of future mathematics educators by delving into the content of Space Analytical Geometry and identifying potential enhancements. The type of research is design research involving 38 Mathematics Department students and FMIPA UNM students. The research instruments used are Lesson Plans and e-tasks. The e-Task is the instrument combining the LMS Syam-OK and Gdrive for collecting the outputs of these activities. The results suggest that 1) students' representation approaches depend on their knowledge level, with broader knowledge leading to diverse presentation information. 2) The complexity of given questions influences the development of students' representation methods. 3) An analytical approach is employed for specific problems requiring visual elements in the solution. The implications call for adjustments by presenting challenging problems that impact the flexibility of methods and the variety of exercise materials supporting the enhancement of representation abilities.

Keywords: Representation Ability; Space Analytical Geometry

Information of Article

Subject classification	*97C30 Cognitive processes, learning theories (aspects of mathematics education)*
Submitted	*20 October 2022*
Review Start	*23 October 2022*
Initial Review Finish	*20 November 2022*
Round 1 Finish	*5 January 2023*
Round 2 Finish	*17 February 2023*
Accepted	*6 June 2023*
Published	*19 November 2023*
Similarity Check	*4%*

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Abstract

Penelitian ini bertujuan untuk mengungkap keterampilan representasi mahasiswa calon guru matematika dengan mendalami materi Geometri Analitis Ruang dan mengidentifikasi peningkatan yang dapat dilakukan. Jenis penelitian ini adalah penelitian desain yang melibatkan 38 mahasiswa Departemen Matematika, FMIPA UNM. Instrumen penelitian yang digunakan adalah Rencana Pelajaran dan e-Task. E-Task merupakan instrumen yang menggabungkan LMS Syam-OK dan Gdrive untuk mengumpulkan hasil kegiatan tersebut. Hasil penelitian menunjukkan bahwa 1) pendekatan representasi mahasiswa bergantung pada tingkat pengetahuan mereka, semakin luas pengetahuan menghasilkan informasi presentasi yang lebih beragam. 2) Kompleksitas pertanyaan memengaruhi perkembangan metode representasi mahasiswa. 3) Pendekatan analitis digunakan untuk masalah tertentu yang memerlukan elemen visual dalam solusinya. Implikasinya menuntut penyesuaian melalui penyajian masalah yang menantang, yang memengaruhi fleksibilitas metode dan ragam materi latihan untuk mendukung peningkatan keterampilan representasi.

INTRODUCTION

Representation ability is an ability that is important not only for students (Kohl & Finkelstein, 2005; Surya et al., 2013) (Nasrullah et al., 2021), especially in learning mathematics, but also this ability is important for students in higher education because they become a central issue in mathematics teaching (Elia & Gagatsis in (Gervasoni, 2006). This ability requires concepts and uses them to communicate the user's understanding of a given problem with mathematical ideas (De Cock, 2012); this is because, unlike other scientific domains, a construct in mathematics is only accessible through its semiotic representation and in addition, one semiotic representation by itself cannot lead to an understanding of the mathematical object it represents (Duval, 2006). In addition to increasing the user's mathematical knowledge, for example, solving arithmetic problems (Elia & Gagatsis in Gervasoni, 2006)), the placement of the proper representation will support mathematical problem solving on the right track where applying these representations requires different strategies (Kohl & Finkelstein, 2005). Not infrequently, students fail to construct the expected problem-solving caused by failure at the representation stage (Surya et al., 2013). Therefore, teachers need to provide opportunities for students to solve mathematical problems as well as mathematical understanding and representation (Minarni et al., 2016); it is even hoped that the student's representation ability should have reached the best level of the specified category.

However, according to (Dewi Sopiany, 2017), students still have low representational abilities to create problem situations based on the data or representations given. Of course, this will impact students' lack of skills in generating ideas, asking questions, and responding to other people's questions or opinions (Widakdo, 2017). Research (Minarni et al., 2016) reveals that students' ability to represent essay questions is still relatively low. In addition, Sari et al. (2018) examined student errors in mathematical representation tests. The results showed that students made mistakes in solving problems involving arithmetic symbols, namely concepts related to characters, and applying other mathematical concepts. Thus, students' mathematical representation skills still require special attention and action to be improved (Saputri & Kamsurya, 2020).

This low ability shows the need for attention because students use representation to support their mathematical understanding by constructing abstract ideas into concrete ideas using logical thinking; representation is something that represents something else (Duval, 2006). Because representation is a sign or configuration of signs, characters, or objects that mark and configure to represent, describe, or represent something other than itself. So that it will support students to learn and communicate, connecting mathematical concepts to solve problems in each project. Representation as one of the standard processes shows that the process of learning mathematics in schools must develop students' representational abilities. Mathematical representation is the ability to represent a mathematical problem through symbols, images, manipulative objects, and other mathematical ideas (Farokhah et al., 2019).

This problem does not need to occur for prospective teacher students because it will facilitate students to learn mathematics later. For this reason, when becoming a teacher, the representation ability has developed very well so that it does not experience difficulties directing students to mobilize these abilities. This avoids what happened to South Sumatra and Bangka Belitung teachers, where 48.4% could correctly represent symbolic representations into graphic representations (Hapizah et al., 2019). Undoubtedly, teachers should teach students in such a way that students can solve mathematical problems as well as mathematical understanding and representation (Minarni et al., 2016). One of the challenges they will face is that students can use symbolic representations to find solutions to problems. They can perform mathematical operations based on known data from the problem. However, this ability is not well developed for all students; most students still struggle to solve problems using symbolic representations correctly. This makes it difficult for students to solve problems involving mathematical expressions or symbolic representations (Farokhah et al., 2019) (Ruslan et al., 2017).

For this reason, the transposition of student to think as teacher candidates need to be trained as suggested by (Utami et al., 2019) (Nasrullah et al., 2017). It is possible that most students experienced the same as those who still have low mathematical representation skills and have difficulty understanding problems and correctly writing equations. Students are not used to solving problems through visual, verbal, and symbolic representations. Therefore, prospective teachers must be trained in students' mathematical representation skills by applying the multiple representation learning model, which uses transpositive work in order to reach they can reach the point that knowledge transposed is itself bettered (Chevallard & Bosch, 2020). Farokhah et al. (2019) in their research, the results showed that the obstacles experienced by students in representing a mathematical problem were triggered by the limited ability to visualize a problem in the form of other mathematical models, the limitations of students in connecting the knowledge they already had with the form of representation. A mathematical problem and limitations in applying mathematical concepts so that they cannot be represented correctly. Another factor that also affects students' representational abilities is student flexibility. Thus, a prospective teacher who will facilitate students in learning activities needs to improve the way in visualizing, connecting, and applying mathematical concepts flexibly so that the process of interpreting and constructing knowledge based on the given problem can develop properly.
Therefore, this study works to explore the extent to which student-teacher candidates progress in developing their representational abilities to solve spatial analytic geometry problems.

METHOD

To carry out this research, the initial activity was to design learning activities that prospective teacher students would participate in. Their activities for this course contain the following materials: 1) Three-Dimensional Space, 2) Point Distances in Three-Dimensional Space, 3) Coordinates of Points in Cartesian, Tube, and Spherical Spaces, and 4) Vectors in Three-Dimensional Space. To observe the progress of students' learning in this study, observations were made not only when they responded to problems given in class but also through tasks that were collected virtually. Students collect assignments through LMS Syam-OK and connect them to GDrive or e-Task (Nasrullah & Baharman, 2018). Through this e-Task, we can easily make virtual observations and facilitate students to collect assignments anytime and anywhere. The research subjects involved were 38 people from students of the mathematics education study program majoring in mathematics, FMIPA UNM. Therefore, this research is supported by a research instrument in the form of a compilation of student assignments stored on the G-Drive.

In the learning activity design process, the learning environment contains three entities: learning objects, learning services, and sub-environments (Koper & Olivier, 2004). In this case, the learning objects are entities used in learning, such as books, websites, and other learning resources. Some learning resources other than the books used, for example, brilliant, topper, cuemath, and others. Then, the learning services used are in the form of services needed for learning, such as learning resource services, communication services, and monitoring services. This learning service tool involves Google Drive and LMS Syam-OK. While in the activity design, there are three components to be considered: the name of the activity, the goal, and the output. Overall, this process is shown in the following diagram.

Figure 1 shows how to provide lecture activities. In lecture activities, several stages are carried out, starting from 1) Preparation, a stage where the activity begins with preparing all lecture needs, including Semester Learning Plans (RPS), Lecture Materials, and Publication Media (for example, e-Task). 2) Input Lecture Materials, the next stage where lecture materials are presented through publication media and prepared to be distributed to students. 3) Learning Interaction: There

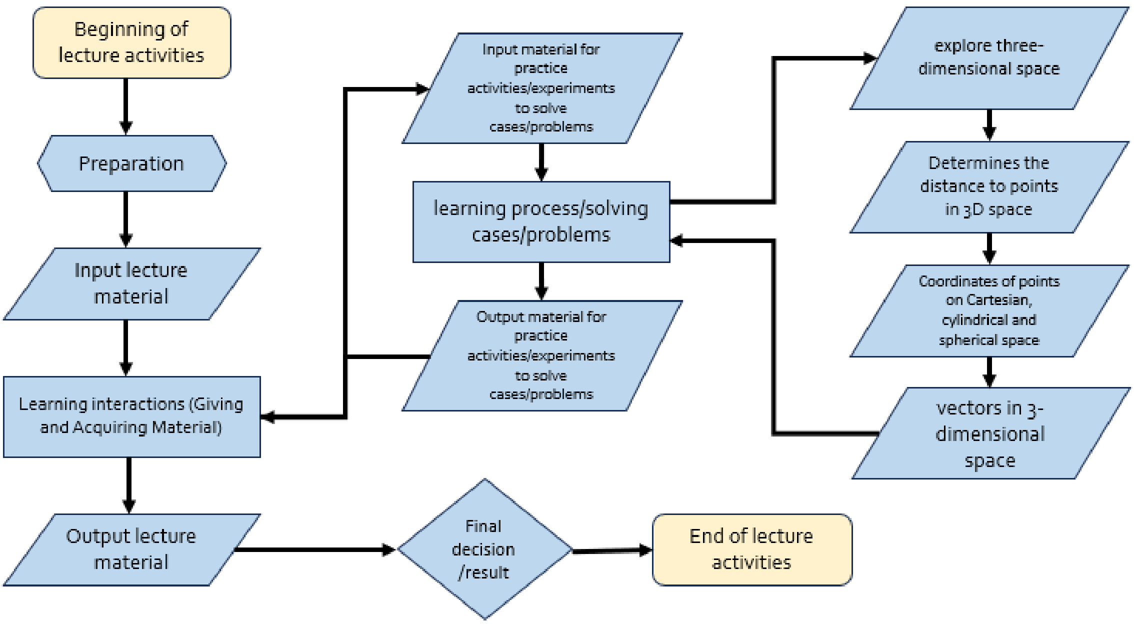


Figure 1. Flowchart of Giving Lecture Activities

are two main processes at this stage: provision and acquisition of material. In this case, the provision of material meant that students were given material prepared by the teacher in various forms, written, presented through an electronic LMS, and others. When material input is carried out, the expected activities are oriented toward practice activities, experiments, and case/problem-solving. Then acquisition can mean that students actively get various materials determined and prepared for lecture activities through the LMS or in the e-Task system. This acquisition activity is directed toward learning or solving cases/ problems. Therefore, the targeted outputs are activities and outcomes related to exercises, experiments, case-solving, or problem-solving. The sub-environment in lecture activities is designed in such a way that it supports the expected learning process. To achieve the expected target, as shown in the picture, four lecture activity topics are placed in the learning process. These four topics are directed at providing learning opportunities for students so that the expected representational abilities and information support the target of this research.

To support the trustworthiness of this research, four criteria of the approach used are credibility, transferability, dependability, and confirmability (Stahl & King, 2020). For the credibility criteria, the consistency of the research findings is shown by comparing the artifacts of analytic geometry space learning with the observations in the classroom. This process takes place for transferability by observing the tendencies for the four given activity contexts. Students' response to the situation is the essence of the transfer process in the activity. In fulfilling the dependability criteria, peer debriefing is one stage to ensure that the entire process is carried out with the correct approach. However, confirmability is not fully passed to ensure that the scope of objective reality is as far as possible. In general, to ensure that the entire process has placed the trustworthiness criteria as a complementary part of the reliability of this research result.

RESULTS AND DISCUSSION

Results

To obtain the expected research results, first, design learning activities that course participants will follow before the lecture begins. The following activities are designed to support research:

Table 1 Learning Activities

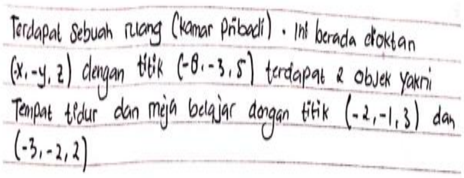
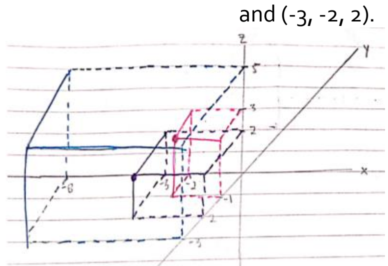
Activity Name	Goal	Output
Explore Three-Dimensional Space	Students can explore the characteristics of three-dimensional space	The ability to represent three-dimensional space and its characteristics.
Determining the Distance of Points in Three-Dimensional Space	Students can determine and predict distances in three-dimensional space	The ability of representation in determining and predicting distances in three-dimensional space
Coordinates of Points in Cartesian, Tube, and Spherical Space	Students can use Cartesian, cylinder, and spherical coordinates to place points.	Representational ability to use Cartesian, cylindrical, and spherical coordinates to place points.
Vectors in Three-Dimensional Space	Students can be able to define and operate vectors in three-dimensional space.	Representational ability to define and operate vectors in three-dimensional space

These activities include lecture activities, which were carried out for eight meetings; the research results are shown in the following figure.

Activity 1: Explore Three-Dimensional Space

In this activity, students are asked to identify objects around them. After that, they use the object as a representation of three-dimensional space. Like what they illustrate, this will be interesting as the development of ideas or bringing objects into the surrounding environment.

Table 2. Construction of Student Answers on the Topic of Exploring Three-Dimensional Space

No	Student Answer Construction	Description
1	You are asked to look for everyday objects that are then used to illustrate three-dimensional space. Show the three-dimensional space on the object!	Problems given to students
2	 Terdapat sebuah ruang (kamar pribadi). Ini berada di oktan (-x, -y, z) dengan titik (-8, -3, 5) terdapat 2 objek yakni Tempat tidur dan meja belajar dengan titik (-2, -1, 3) dan (-3, -2, 2)	
	There is a room (private room). It is in octane (-x, -y, z) with dots (-8, -3, 5). There are two objects, namely the bed and study table, with dots (-2, -1, 3) and (-3, - 2, 2)	Solving a given problem is by selecting the context of a private room. Three objects are illustrated in the room: a bed and a study table. These two objects are represented by two dots (-2, -1, 3) and (-3, -2, 2).
3	 The dot image in the three-dimensional Cartesian space above is shown to place objects in the private room.	

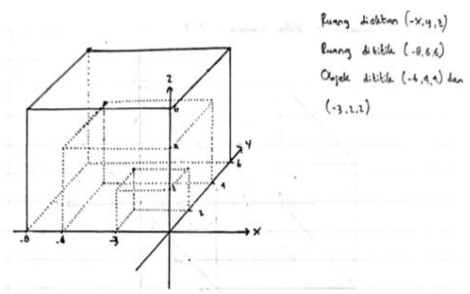
In Table 2, the problem given is looking for objects that exist in everyday life. The object relates to the use of three-dimensional space. A private room is used as an illustrated situation for a three-dimensional space in a student's work. This room represents the concept of a three-dimensional space built by the student. However, the object introduced in this case is only in the form of a point. At least the placement of these objects initiates the use of the concept of space in the study of analytic geometry. Of course, the ability that is built with this activity is exploratory. Not infrequently, this ability is used mainly in situations of recognizing space. With good space recognition, the benefit that can be obtained is the placement of the proper object at the right point so that, in turn, it will impact optimizing the space based on its designation.

From this description, what is shown by the students from their work follows the following stages: 1) Identification of objects related to daily life; in this case, the chosen one is a private room. 2) Connect the situation of the private room with the illustration of the three-dimensional space. 3) Using the concept of three-dimensional space and objects in the private room, the object is represented by a point. 4) Use pictures to visualize what was done in steps 1, 2, and 3.

Activity 2: Determining the Distance of Points in Three-Dimensional Space

Distance is an essential part of the use of space. Determining the distance between two or more objects requires recognizing the object's distance. The distance norm can mathematically calculate the distance between two objects (|d|, d = distance). For three-dimensional space, the object's position is different compared to two-dimensional space. Even so, the position of objects in space is determined by the three dimensions that place the object in its place. For students in Space Analytical Geometry learning, distance learning is not only training to determine the distance norm, but they need to take advantage of space to place objects and calculate the distance between them—object loci in space.

Table 3. Construction of Student Answers Topic Determining Distances to Points in Three-Dimensional Space

No	Student Answer Construction	Description
1	Hitunglah·jarak·kedua·titik·pada·gambar·tugas·sebelumnya¶ Calculate the distance between the two points in the previous task drawing!	Problems given to students
2	Diketahui·:·A=(-6,4,4)·dan·B=(-3,2,2)¶ The prepared completion plan begins by identifying the information from the given problem.	
3	$d(AB) = \sqrt{\lvert(-3)-(-6)\rvert^2 + \lvert 2-4\rvert^2 + \lvert 2-4\rvert^2}$ $= \sqrt{3^2+2^2+2^2}$ $= \sqrt{9+4+4}$ $= \sqrt{17}$ The problem-solving process is applied using the known distance formula. Applying the formula used shows no problems running well and smoothly from the work shown.	
4	 Draw points in three-dimensional Cartesian space.	

In Table 3, the challenge given to students is determining the distance by placing objects in the previous assignment. Based on these questions, as seen from what the students did, before determining the distance between objects in space, the placement of objects in space, for example, Cartesian coordinates, was done as a form of object orientation. In this orientation activity, it is not easy to orient this object, where three dimensions of space must be considered to ensure that the object's placement is in the right place. As described in Table 3 above, the usual method follows the following procedure: 1) Plot the points on the x, y, and z axes; 2) Determine the position where the x and y points meet in the XY plane; 3) Lift the point (x, y) corresponds to the position of the point on the z-axis. This is also done at other points; for example, points A(-6, 4, 4) and B(-3, 2, 2) are in the task.

After the position of the two points is placed in space, the distance determination (d(AB)) is carried out using the distance formula in space, and as shown in the figure, the distance AB is the $\sqrt{17}$.

Some of the representations used in this procedure stem from the placement of points on the axes of the coordinate system. The representation in the same way is also applied to other points. Because determining the distance requires more than one point, it takes a minimum of 2 points. To make it look more precise, the representation of these points is visible using pictures. So, object representation is done in addition to placing points or objects; it is also equipped with forming images using dotted lines to ensure the accuracy of objects in space.

Activity 3: Coordinates of Points on Cartesian, Cylindrical Spaces, and Spheres

For the activity in this section, students are given problems in the form of questions that expect them to convert points in the coordinate system. The conversion is directed from three-dimensional Cartesian coordinates to cylindrical and spherical space coordinates.

Table 4. Student Answer Construction Topic Coordinates of Points on Cartesian, Cylindrical, and Spherical

No	Student Answer Construction	Description
1	Diketahui titik P(1,1,1) pada sistem koordinat ubahlah posisi titik tersebut untuk sistem koordinat tabung & bola! Given the point P(1, 1, 1) in the coordinate system, change the position of the point for the cylindrical and spherical coordinate system!	Problems given to students
2	Penyelesaian : Dik: $P(1,1,1)$ → x, y, z Tabung → $P(r,\theta,z)$ Bola → $P(\rho,\theta,\varphi)$ Completion plans are arranged in an excellent systematic manner. It begins by presenting the known information, and the representation of the question in the problem is made in the form of an arrow diagram that connects the type of space and the arrangement of its coordinate points.	
3	Mencari komponen yang diperlukan untuk menentukan koordinat dari tabung dan bola • $r=\sqrt{x^2+y^2}$ $=\sqrt{1^2+1^2}$ $=\sqrt{2}$ $Tan\,\theta=\frac{x}{y}$, $Tan\,\theta=1$, $\theta=45°=\frac{\pi}{4}$ • $\rho=\sqrt{x^2+y^2+z^2}$ $=\sqrt{1^2+1^2+1^2}$ $=\sqrt{3}$ • $r=\rho\sin\varphi$, $\sin\varphi=\frac{r}{\rho}$, $\sin\varphi=\frac{\sqrt{2}}{\sqrt{3}}$, $\varphi=\arcsin\frac{\sqrt{2}}{\sqrt{3}}$, $\varphi=54,74°$ • $z=\rho\cos\varphi$, $\cos\varphi=\frac{r}{\rho}$, $\cos\varphi=\frac{1}{\sqrt{3}}$, $\varphi=\arccos\frac{1}{\sqrt{3}}$, $\varphi=54,74°$ The problem-solving process shown in the figure to the right is to parse any components and determine their values. The description of the values obtained is then used to answer the core questions of this problem.	
4	Tabung → $P(r,\theta,z)$ → $P(\sqrt{2},\frac{\pi}{4},1)$ Bola → $P(\rho,\theta,\varphi)$ → $P(\sqrt{3},\frac{\pi}{4},54.74°)$ The conclusions obtained from the problem-solving process are based on the questions attached to the problem and adjusted using the results of the problem-solving process shown previously.	

Understanding how to convert point coordinates from Cartesian to cylindrical and spherical coordinates requires knowledge related to it. The knowledge in question is what the coordinates for the cylindrical space and spherical space look like. For the cylindrical space coordinates it is filled by (r, θ, z), and the spherical coordinates are filled by (ρ, θ, ϕ). R = ρ; therefore, θ in cylindrical space is also used for spherical space, but spherical space is formed from the angle from the xy-axis region and the z-axis. Then, for the cylinder space, the height of the cylinder is none other than the z-axis, so the third point in the coordinates of the tube space is the z-axis. Meanwhile, for a spherical space where the symbol used is ϕ, the angle formed between the z-axis and ρ.

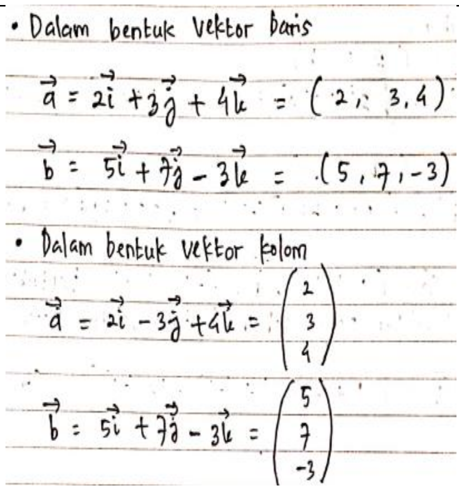
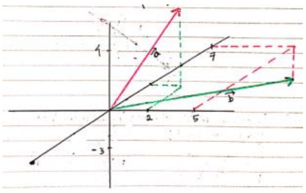
Based on this review, the working steps taken by students were as follows: 1) Identifying the coordinates of each space converting Cartesian to cylinders and spheres. 2) Determine some required values, for example, for tubes r and θ, while for balls, namely ρ dan ϕ. After all that is needed is complete, these values are used to complete the coordinate components of each space.

Activity 4: Vectors in Three-Dimensional Space

For the activity in this section, students are given problems in the form of questions that expect them to create vectors placed in a three-dimensional space coordinate system. The results are shown in the table below.

Table 5. Construction of Student Answers on the Topic of Vectors in Three-Dimensional Space

No	Student Answer Construction	Description
1	Silahkan buat vektor pada ruang tiga dimensi ! Please vector in three-dimensional space!	Problems given to students

No	Student Answer Construction	Description
2		The problem-solving process shown in this issue is very well developed. The presentation of the given vectors begins by giving a general shape before being converted into row vectors and column vectors. In other words, student work has progressed with some review, such as column and row vectors.
3		Draw points in three-dimensional Cartesian space. This picture shows two octane chambers, namely octane 1 (xyz) and 5 (xy-z), are used. The use of 2 different colors, red and green, indicates these vectors' presence. This is a good attempt at demonstrating the quality of performance.

Although the questions given explore students' knowledge and understanding by asking, "Please create a vector in a three-dimensional space!" this question requires creative responses from students where they are expected to create a three-dimensional space whose contents are vectors. Knowledge is needed in addition to three-dimensional space and vectors with values and directions to answer this question. In addition to writing examples of vector numbers, students are also expected to be able to visualize the vector's shape depicted in the three-dimensional space.

Table 5 shows students' declarative knowledge through how the answers are given, namely row and column vectors. In other words, the description of the answer shows what the student knows. Then, the response to the questions is continued by visualizing the vector in the three-dimensional space. For this reason, number 3 in Table 5 shows a three-dimensional space image with vectors given in red and green colors.

Discussion

From the research findings stated above, the representation shown by students in their work is described in the following description:

The methods and materials of student representation depend on their knowledge and the broader knowledge of the various presentation information provided. What is meant in identifying objects where the selected object is related to daily life? In this case, the chosen one is a private room. Then, connecting the situation of the private room with the illustration of a three-dimensional space involves representation, such as the representation of objects in the private room in the form of dots. With this object, representation supports the visualization of images in three-dimensional space. Developing representation skills requires understanding mathematical concepts and attaching their relation to other mathematical concepts (Allen et al., 2020). Through the relationships between these concepts, representations can be used to recognize the relationships between concepts and apply them to realistic problems through modeling (Meilon et al., 2019). In its implementation, it emphasizes that the knowledge and learning experiences possessed and developed by students can lead them to demonstrate their representational abilities to be richer and support ways of solving problems or experiences to develop knowledge, use media, and practice problem-solving (Astuti, 2017). (Kozma, 2003) suggests that this representational ability provides learners with an authentic learning environment in which they use these abilities to explain phenomena. The ability to represent an object is also a form of confidence in interpreting and communicating mathematical concepts through abstract symbols that can be understood logically (Nurlisna et al., 2020). Indirectly, the learning process built with representational abilities forms a learning environment that enriches the learner's experience.

Then, object representation is usually supported by treatment in the form of placing points or objects that are equipped with forming images using dotted lines to ensure the accuracy of objects in space. Whatever is done is part of the form of representation where they think about the problem and valuable tools to solve the problem (Sabirin, 2014). In line with the explanation (De Cock, 2012) that the ability of representation or the ability of multiple representations can be a valuable tool to facilitate problem-solving. Although it is not stated that the goal is an abstraction, the formation of valuable learning experiences may be in line with the argument (Kaput, 1989) that the learning outcomes can be used for further learning activities where it is possible to see complex ideas in new ways and apply them more effectively. Mathematical understanding and representation are integral to problem-solving (Minarni et al., 2016). That way, improving mathematical representation skills will lead students to improve their problem-solving abilities.

Representation activities become complex when converting point coordinates from Cartesian to tube and spherical coordinates. In addition to requiring knowledge related to this, students will also explore the components needed to obtain converted points. (Kaput, 1989) found that using multiple representations helped students better understand mathematical concepts and provided various concretizations of concepts. This description relies on differences in the performance shown by students (Kohl & Finkelstein, 2005), suggesting that differences in performance depend on several things, including student expectations, prior knowledge, metacognitive skills, and specific contextual features of the problem and representation.

The development of previous knowledge can be done by asking questions that require creative responses from students or users; if this is done, student performance will develop according to the challenges given. Working on the problem of representation ability will direct the user to propose strategic considerations based on the characteristics of the problem at hand (Munn et al., n.d.). Although it is different from (Hegarty & Kozhevnikov, 1999), where the use of pictorial representations is negatively related to success in solving mathematical problems, in student performance, this is getting clearer and better developed using pictures and connecting the reasonable opinion that has been put forward where representation is a kind of configuration process to present something in different situations which involves identification, selection, and conveying of ideas (Goldin, 2015; Fennema et al., 1999); (Seeger et al., 1998). Other implementations were Nurlisna et al. (2020) by utilizing software and developing its function as a medium to present other learning tools in the form of a worksheet. The goal is that mathematical representation skills developed in learning activities are not only the instructions needed to be precise but also to facilitate the development of these skills to support the achievement of the expected learning objectives. The research implies that this kind of learning opportunity must be prepared by teachers to students to prospective teacher students so that they not only hone their mathematical understanding and representation (Minarni et al., 2016), especially students as prospective teachers who are enriched with knowledge leads to creative skills. Also, enhancing skills that utilize such knowledge enriches the learning experience (Cambaya & Tan, 2022). However, the research has several constraints and limitations regarding developing students' knowledge, where representation activities would further flourish if supported by visualization activities. Hence, this study would be interesting to explore visualization activities. Naturally, other skills would develop as part of the representation ability.

Implication

The importance of nurturing representation skills in mathematics education cannot be overstated. These skills involve comprehending mathematical concepts and establishing connections with other mathematical ideas. By refining representation skills, students can recognize the relationships between concepts and apply them to solve real-world problems through modeling. Implementing learning underscores that students' knowledge and learning experiences can lead them to demonstrate more robust representational abilities, supporting effective problem-solving and knowledge development using media and practical application in problem-solving. Representation skills also foster an authentic learning environment where students can elucidate phenomena and build confidence in conveying mathematical concepts through logically comprehensible symbols.

The complexity of representation activities in the mathematical context, especially in point coordinate conversion and the use of multiple representations, aids in developing prior knowledge and leveraging visuals to enhance the understanding of mathematical concepts. Despite constraints and limitations in students' knowledge development, there is potential for further enhancement through visualization activities. This writing emphasizes the urgency and positive impact of developing representation skills in improving students' understanding and mathematical proficiency.

Limitation

However, the limitations of this study lie in the lack of detailed exploration regarding which aspects of students' representation skills have reached an optimal level. Therefore, the foundation for improvement and skill enhancement can be identified by developing problems or learning activities. Additionally, the insights gained from this research are expected to reveal the extent of students' representation skills, shedding light on areas that may require improvement, particularly concerning the complexity or visualization aspects of representation skills.

CONCLUSION

Based on the discussion stated above, the research results obtained lead to conclusions that can be drawn as follows: 1) Involving problems in everyday life is one way to explore students' representational abilities, 2) Complex and non-routine problems will trigger students to develop representational skills where they will explore various related information to solve the problem. 3) The challenges given to students should trigger creative responses from students so that they not only form knowledge but also have a good learning experience. 4) Visualization techniques in pictures, diagrams, or other similar are the right opportunity for students to develop representational abilities.

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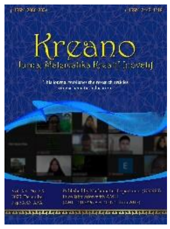
Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 293-308



Numeracy-Based Teaching Material with Data Presentation Topic to Support Students' Numeracy Skills

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Abstract

Numeracy is the ability to identify, describe, and communicate various types of numbers and mathematical symbols to solve mathematical tables, graphs, and problems. There are few math teaching materials, especially those based on numeracy. The research aims to produce numeracy-based teaching material that is valid, practical, and potentially supports numeracy skills. The following type of research is development. The research subjects were students of class VII at Senior high school in Pagar Aam. The stages of the research consisted of preliminary study and formative evaluation (Expert Review, One to One, Small Group, and field tests) with the instruments used, namely questionnaires, tests, and interviews. This study states that the teaching material used can help improve numeracy skills, and the developed teaching material is declared valid without revision. This shows that with the help of numeracy-based teaching, the material can help students improve their numeracy skills in understanding data presentation material. Mathematics teachers can further use these numeracy-based teaching materials to improve students' numeracy skills.

Keywords: Numeracy; Presentation of Data; Teaching Materials.

Information of Article

Subject classification	*97D40 Mathematics teaching methods and classroom techniques*
Submitted	*10 January 2023*
Review Start	*11 January 2023*
Initial Review Finish	*11 January 2023*
Round 1 Finish	*21 January 2023*
Round 2 Finish	*29 March 2023*
Round 3 Finish	*29 May 2023*
Accepted	*30 May 2023*
Published	*22 November 2023*
Similarity Check	*10%*

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Abstrak

Numerasi adalah kemampuan untuk mengidentifikasi, menjelaskan dan mengkomunikasikan berbagai jenis bilangan dan simbol matematika untuk tujuan pemecahan tabel, grafik dan masalah matematika. Belum *banyak bahan ajar matematika khususnya yang berbasis numerasi. Tujuan penelitian ialah menghasilkan bahan ajar berbasis numerasi yang valid, praktis dan berpotensi mendukung kemampuan numerasi. Jenis penelitian ialah pengembangan. Subjek penelitian adalah peserta didik kelas VII disalah satu SMP Negeri di Kota Pagar Alam. Tahapan penelitian terdiri dari preliminary study dan formative evaluation (Expert Review, One to One, Small Group dan field test) dengan instrumen yang digunakan yaitu angket, tes dan wawancara. Penelitian ini menyatakan bahwa bahan ajar yang dikembangkan dinyatakan valid, praktis, dan memiliki efek potensial terhadap kemampuan numerasi peserta didik. Hal ini menunjukkan bahwa dengan bantuan bahan ajar berbasis numerasi dapat membantu peserta didik menumbuhkan kemampuan numerasi peserta didik khususnya materi penyajian data. Bahan ajar berbasis numerasi ini dapat digunakan guru dalam mendukung kemampuan numerasi peserta didik.*

INTRODUCTION

Mathematics is a tool used to complete any tasks in everyday life (Başman & Kutlu, 2020; Bütüner & Baki, 2020; Diego-Mantecón et al., 2021). Because mathematics is essential, learning mathematics must be instilled from an early age. (Anggraeini, 2022), because the higher the level of education, the more difficult solving mathematics problems will be. (Hapizah, 2017). Developing problem-solving skills is also essential because mathematics is often found in everyday life (Syifa et al., 2022).

One of the topics in mathematics is data presentation. Data presentation is part of mathematics with collecting, compiling, and describing information in tables or charts and investigating the information obtained to obtain goals or conclusions. (Susanto et al., 2021). Students are said to understand mathematics well, including if they can use symbols well (Hapizah et al., 2017). The students' skills in presenting data and using symbols still need improvement. This statement aligns with research results stating that students did not understand, could not interpret, and could not use words, notations, symbols, and structures to present mathematical ideas properly. (Hidayati & Prabawanto, 2022). The students' skills in communicating their mathematical ideas through good writing still need to improve (Fawziawati, 2022). The lack of learning facilities and media for students to support learning the data presentation topic, especially presenting data in tabular form, is one of the causes. (Farida et al., 2022; Ferawati et al., 2021).

The activities on the data presentation topic are included in numeracy skills. Numeracy is the knowledge of using various numbers and basic mathematical symbols to solve problems in everyday life, analyzing information presented in various forms, and interpreting the results of the analysis to predict and make decisions. (Kemendikbud, 2017). Improving numeracy skills can help students count or calculate when learning mathematics (Ketaren et al., 2022). Several indicators used as a reference to determine the extent to which students' numeracy skills are: 1) the use of symbols and numbers when solving problems in the context of everyday life related to basic mathematics, 2) the ability of students to analyze information, whether in the form of charts, diagrams, tables, and graphs, 3) the ability of students to interpret the results that have been done, both in predicting and providing conclusions (Kii et al., 2021). Numeracy also refers to the appreciation and understanding of information expressed mathematically, such as graphs, charts, and tables (Mahmud & Pratiwi, 2019).

One of the causes of students' low numeracy skills is their low ability to understand problems, interpret data, and use words, notations, symbols, and structures in presenting mathematical ideas. (Hidayati & Prabawanto, 2022). This is due to the need for more supporting facilities and media. (Farida et al., 2022; Ferawati et al., 2021). Therefore, it is necessary to provide supporting facilities, including teaching materials.

Teaching materials contain the discussed topic, are arranged systematically, and are used by educators and students in the learning process (Setiawan & Basyari, 2017). Another definition of teaching materials is the materials teachers need in teaching-learning topics (Ariani et al., 2019). Teaching materials are all forms of information in text, visuals, audio, or a combination thereof that students need to achieve specific competencies (Mitha Frilia et al., 2020). Teaching materials can significantly increase students' understanding of mathematics (Albany et al., 2022).

The purpose of teaching materials is to make it easier for students to learn existing information according to the topic being studied, to help educators as facilitators with more varied learning materials, and to make learning more exciting and not monotonous by only using books as a learning resource (Laily & Shofiyani, 2021). Using teaching materials related to everyday life will make learning more interesting (Umuhoza & Uworwabayeho, 2021). To achieve student competence in numeracy skills, teaching materials that need to be used in the learning process are teaching materials that can develop these numeracy skills.

The problem is that the teaching materials must fully support students' numeracy skills. Developing teaching materials to support numeracy skills was carried out in research by Setyawati (Setyawati, 2022), who developed module teaching materials for language literacy and numeracy for elementary students and developed mathematics teaching materials for teachers to improve numerical literacy skills. In addition to these two studies, there have been several studies that have developed teaching materials. However, teaching materials focused on students' numeracy skills, especially data presentation topics, have never been done. Research conducted by (Widiantari et al., 2022) regarding numeracy-based e-modules showed that these teaching materials were very effective for students to use in online learning needs. (Mamolo, 2019) has developed teaching materials in the form of DIMac, which has an application for drawing. No research has yet been found that develops numeracy-based teaching materials for the data presentation topic.

For this reason, it is necessary to develop numeracy-based mathematics teaching material on the data presentation topic. Numeracy is adequate for teaching materials during mathematics lessons (Winarni et al., 2021). The data presentation topic as a part of mathematics needs to be improved by designing learning (Partayasa et al., 2020).

Therefore, this research aims to develop numeracy-based teaching material for the data presentation topic in supporting students' numeracy skills. The problem formulation of this research is "Are the numeracy-based teaching materials for the data presentation topic valid and practical and have a potential effect on students' numeracy abilities?"

METHODS

This research uses the type of development research. The development models used are the preliminary research stage and the formative study stage, which consists of Expert Review, One to One, Small Group, and Field Test (Zulfah et al., 2020).

The research subjects were 31 grade 7 students at one of the public junior high schools in Pagar Alam City. The flow in this research is in Figure 1.

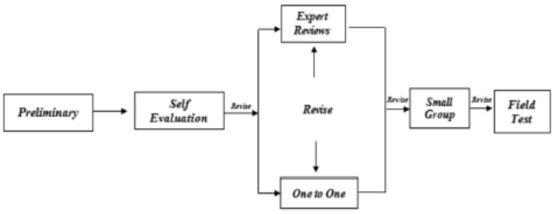


Figure 1 Teaching Material Development Flow (Aulia & Prahmana, 2022)

The steps that have been carried out by researchers at the preliminary research stage, namely 1) the preparation stage to determine the needs of the teaching material and the topic specified in the teaching material, the researchers also take care of research permits, 2) the design stage, the researchers design teaching materials according to components of numeracy-based teaching materials for a data presentation topic, starting from determining the context of activities and designing teaching materials.

The next stage is the formative study stage, which consists of the following stages: 1) Expert Review, the teaching material that has been designed will be evaluated by lecturers who are experts in the field of numeracy; 2) One to One, the stage where the teaching material will be given to three students those with low, medium, and high abilities to identify problems using the teaching material which then the work results will be revised to overcome deficiencies in teaching materials, 3) Small Group, the testing stage of a small group of students where the work results from the small group stage will be revised once again to improve the teaching material, 4) Field Test, during the field test stage, the mathematics teacher for grade 7 at a Public Junior High School in Pagar Alam City will conduct a trial of the teaching material. At this stage, the teacher, as an observer, will observe students using the numeracy-based teaching material.

The data collection techniques in this research were Expert Review validation, questionnaire, test, and interview. Expert Review validation was carried out to evaluate and revise the design of teaching material according to the validation results. The questionnaire was used to see the practicality of Numeracy-based teaching material given at the Small Group stage. The test uses numeracy-based description questions to see the potential effects of numeracy-based teaching material. The interview was used to support the data obtained from the tests' results. The instrument used is an interview guide.

The data analysis techniques used in this research are quantitative and qualitative. The quantitative data analysis stage was obtained from data analysis validation of teaching material, questionnaire, and test. The teaching material validated according to the scoring guidelines using the teaching material validation sheet instrument was grouped according to the validity category (Akbar, 2013). The validity category refers to Table 1.

Table 1 Validity Categories

Category	Validity Level
Not Allowed	0,1-50
Major Revision	50,1-70
Minor Revision	70,1-85
Valid	85,1-100

In collecting questionnaire data, the researcher gave students a questionnaire sheet. Next, the researchers calculated the average score and grouped the average results according to the Practicality Category, which refers to Table 2.

Table 2 Practicality Categories

Category	Practicality Level
< 50	Impractical
50-59	Less Practical

Category	Practicality Level
60-79	Practical
80- 100	Very Practical

The written test data for students were then grouped into three categories: high, medium, and low. The high, medium, and low categories were determined by looking at the Mean and Standard Deviation scores of the students' results (Arikunto, 2013). The test categories are shown in Table 3.

Table 3 Test Categories

Category	Score
High	$x > (M + SD)$
Medium	$(M - SD) \leq x \leq (M + SD)$
Low	$x < (M - SD)$

Qualitative data was used to match the test data results with the interview results using the interview sheet instrument to strengthen the test results carried out by students.

RESULTS AND DISCUSSIONS

Preliminary Stage

In the preliminary stage, the researchers conducted a literature study on numeracy-based teaching materials and the data presentation topic, curriculum analysis, and analysis of students' characteristics. The researchers determined the research location, namely one of the public junior high schools in Pagar Alam city, followed by discussions with the school's grade 7 mathematics teacher. The information obtained from the results of the discussion is that the curriculum used is the 2013 curriculum, the lesson plan used by the teacher is by the 2013 curriculum, the teaching materials used by the teacher have not accommodated students' numeracy skills, and the use of teaching materials as a support for learning is still very minimal.

The next stage is that the researchers designed numeration-based teaching materials for the data presentation topic with due regard to Basic Competencies and Competency Achievement Indicators in the data presentation topic. In addition to designing teaching material drafts, the researchers also designed research instruments in the form of validation sheets, questionnaire sheets, tests, and interview sheets.

Formative Evaluation

The researchers carried out several stages at this stage, namely Self Evaluation, Expert Review, One-to-One, Small Group, and Field Test.

Self-Evaluation

At this stage, the researchers conducted self-evaluation by paying attention to the use of language and the writing layout and reviewing the content, namely data presentation. Overall, the evaluation results stated that the teaching material drafts were as expected regarding content, construct, and language. The content in the teaching material is suitable for the data presentation topic. The teaching material was considered to foster numeracy skills. The language and layout of all components are by the criteria. The results of this stage were called *Prototype 1*.

Expert Review

At this stage, *Prototype 1* was validated by two lecturers and a Mathematics teacher at the research location. Comments given by the validators are presented in Table 4. The results of the assessment given by the validators in terms of content, language, and layout are shown in Table 5.

Table 4 Comments by the Validators

Validator	Comment dan Suggestion
First lecturer	Revise the Learning Objectives and activities in the teaching material and add the answers as line charts.
Second lecturer	Add a bibliography to the teaching material component.
Mathematics teacher	Make the teaching material focused on whether for students or teachers; delete the answers if the teaching material is for students.

Table 5 Expert Review Stage Validation Results

No.	Aspect	Score
1.	Content Eligibility	78.33
2.	Language Eligibility	93.75
3.	Layout Eligibility	89.58
	Average Score	**86.54**

The questionnaire data analysis provided by the validators, as presented in Table 5, shows that the average score is 86.54, with a good category. Based on comments from the validators, *prototype* one was revised, with the revision results shown in Table 6.

Table 6 Revision in the Expert Review Stage

After Revision

Revise the Competency Achievement Indicators:

Indikator Pencapaian Kompetensi
1. Mengenal data dalam kehidupan sehari-hari 2. Memahami cara mengumpulkan data 3. Menganalisis data (tabel, diagram garis, diagram batang, dan diagram lingkaran). 4. Membaca data
1. Menyajikan data dalam bentuk tabel, diagram batang, diagramm garis, dan diagram lingkaran 2. Menafsirkan data dalam bentuk tabel, diagram batang, diagramm garis, dan diagram lingkaran

Revise the learning objectives according to the Competency Achievement Indicators:

After Revision

B. Tujuan Pembelajaran

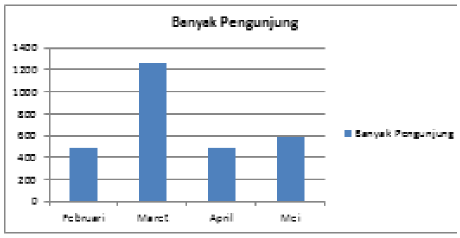
Melalui pembelajaran berbasis numerasi, peserta didik diharapkan mampu :

1. Mengenal data di kehidupan sehari-hari dengan tepat
2. Memahami cara mengumpulkan data dengan tepat.
3. Menganalisis data (tabel, diagram garis, diagram batang, dan diagram lingkaran) dengan tepat.
4. Membaca data (tabel, diagram garis, diagram batang, dan diagram lingkaran) dengan tepat
5. Menyajikan data dalam bentuk (tabel, diagram garis, diagram batang, dan diagram lingkaran) dengan tepat.
6. Menafsirkan data dalam bentuk (tabel, diagram garis, diagram batang, dan diagram lingkaran) dengan tepat.

Add line chart forms in the answers to the questions:

b. Dari tabel yang telah dibuat, buatlah diagram yang sesuai dari informasi tersebut!

Jawaban: Disajikan dengan **diagram Batang atau diagram garis**



Add a bibliography at the end of the teaching material:

L. Daftar Pustaka

Irawati, M. (2018). Profil Minat Dan Hasil Belajar Siswa Dalam Pembelajaran Matematika Kelas Vii I Smp Negeri 5 Yogyakarta Pada Pokok Bahasan Penyajian Data Dengan Menggunakan Media Pembelajaran Kahoot. *Universitas Sanata Dharma, Yogyakarta.* https://repository.usd.ac.id/31126/2/141414006_full.pdf

Maghfiroh, L., Mustangin, & Fuady, A. (2020). Analisis Kesulitan Pemahaman Konsep Matematis Peserta Didik dalam Menyelesaikan Soal pada Materi Penyajian Data Kelas VII SMP. *Jurnal Pendidikan, Penelitian, Dan Pembelajaran, 15*(33), 38–45.

One-to-One

Prototype 1, in parallel with the expert review stage, was also validated at the one-to-one stage by three students in the High, Medium, and Low categories. Students have provided comments regarding the readability of the teaching material through students' understanding of the meaning of the sentences in the teaching material. The one-to-one results concluded that students understood the meaning of the sentences in the teaching material.

Small Group

The researchers carried out the Small Group stage with two groups, each consisting of 3 students. Students determination was based on the results of discussions with the mathematics teacher. At the Small Group stage, students were asked to read the numeracy-based teaching material and work on activities on the teaching material provided.

Group 1 and Group 2 collected data and determined the requested tables and charts, namely row-column tables, and bar charts. However, according to the students, the activity in the question reinforcement section needed to be explained. Students need to read repeatedly to understand the questions. For this reason, the researchers revised the activities seen in Table 7.

Table 7 Revision in the Small Group Stage

Before Revision

Buatlah penyajian data siswa yang pernah berkunjung ke tempat wisata yang ada di Kota Pagar Alam, contohnya seperti Tugu Rimau, Ayik Pacar, Green Paradise, Tangga Seribu, dll. Tiap kelompok dapat menentukan empat tempat wisata. Siswa dapat berdiskusi untuk menayakan tempat wisata mana yang pernah dikunjungi teman di kelas. Buatlah tabel dan diagram apa yang sesuai untuk menampilkan data tersebut! Apa kesimpulan dari data yang sudah kamu buat?

After Revision

Buatlah penyajian data dari siswa yang pernah berkunjung ke tempat wisata yang ada di Kota Pagar Alam, seperti Tugu Rimau, Ayik Pacar, Green Paradise, Tangga Seribu, Kebun Teh dan Dempo Park. Siswa dapat berdiskusi untuk menayakan tempat wisata mana yang pernah dikunjungi teman satu kelompok. Kemudian kerjakan aktivitas di bawah ini!

1. Tentukan jenis tabel dan diagram apa yang sesuai untuk menampilkan data tersebut! Lalu gambarkan tabel dan diagram tersebut sesuai dengan data yang kamu miliki!
2. Apa kesimpulan dari data yang sudah kamu dapatkan?

After working on activities on the teaching material, students were asked to respond to the teaching material through a questionnaire sheet. The results of the analysis of students' questionnaire sheets at the Small Group stage are shown in Table 8.

Table 8 Questionnaire Results

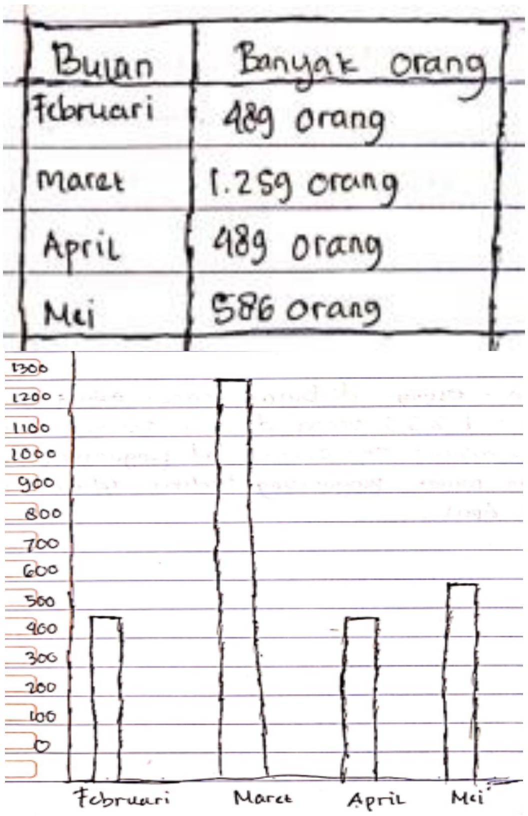
No.	Student's Initials	Questionnaire Score
1	DT	91.07
2	GW	89.29
3	AV	92.86
4	SN	89.29
5	TR	87.50
6	CL	92.86
Average Score		**90.48**

Based on Table 8, the average result of the questionnaire calculation score is 90.48. This shows that the numeracy-based teaching material that has been developed was included in the efficient category.

Field Test

The teaching material declared valid and practical from the stages described above was tested more broadly through the Field Test stage. At this stage, the model teacher was Mrs Suratini, S.Pd., a mathematics teacher for grade 7D. The model teacher learned the data presentation topic at this stage using learning resources in the developed teaching material. The model teacher completed the learning process using a previously validated lesson plan.

The activities carried out by students have followed all the instructions in the teaching material. One of the student work results from the given activity is shown in Figure 3.



Bulan	Banyak orang
Februari	489 orang
Maret	1.259 orang
April	489 orang
Mei	586 orang

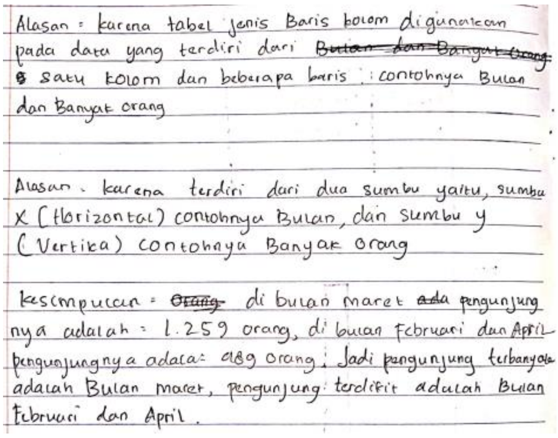


Figure 3. Field Test Work Results for Group 1

From Figure 3, indicator 1, namely determining the use of numbers and symbols, needed to have been done better, where students did not write down the x-axis and y-axis. For indicator 2, namely determining the type of tables and charts and giving reasons, group 1 answered correctly. The reasons given by Group 1 were correct and to the information in the Monpera Museum activity data. For indicator 3, namely writing conclusions, group 1 was correct in concluding. However, the group's answers needed to be corrected when making a column row table because they had yet to write down the number of visitors at the table's end, totaling 2,823.

Judging from the results of the students' work when working on the numeracy activities in the teaching material, students have answered all the question items, although there are still incomplete answers.

After doing all the activities on the teaching material, at the end of learning, the teacher closed the lesson and asked students to provide conclusions from the learning activities. Students were able to conclude reasonably. Next, the model teacher closed the learning activity.

Analysis of Test and Interview Data

The results of the written test in the form of numeracy-based description questions on data presentation topics for grade 7 resulted in an average score of 76.29 in the excellent category. The distribution of students based on low, medium, and high categories is shown in Figure 4.

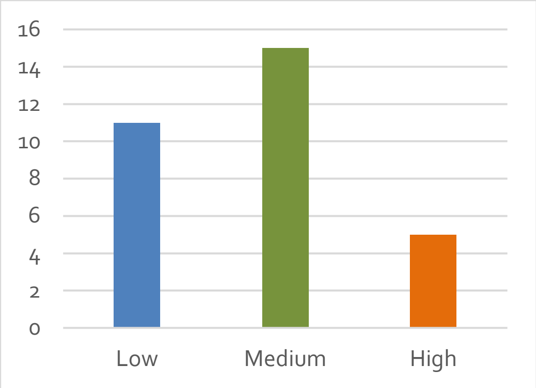
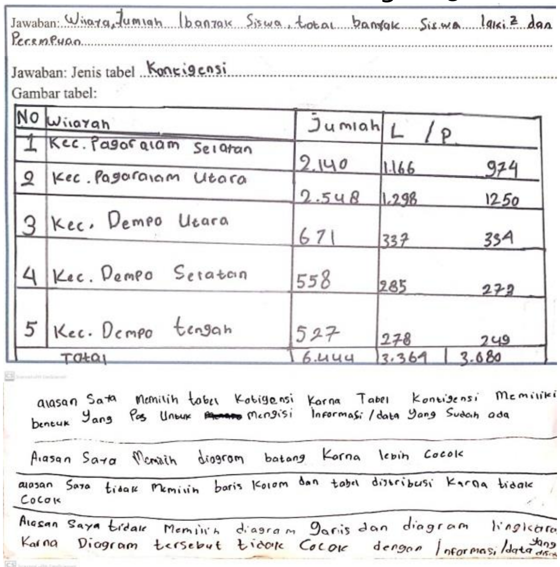


Figure 4. Test Results Distribution

According to students, the teaching material developed is fascinating because the problems came from the context of students' daily lives; the pictures are engaging and help students understand the topic presented in the data. To support the test results, interviews were conducted, with the following results:

Students in the High Category

The student with the initials N is a student in the high category. The work results of student "N" can be seen in Figure 5.


Jawaban: Wilayah, Jumlah banyak Siswa, total banyak Siswa laki2 dan Perempuan

Jawaban: Jenis tabel Kontigensi

Gambar tabel:

No	Wilayah	Jumlah	L	P
1	Kec. Pagaralam Selatan	2.140	1.166	974
2	Kec. Pagaralam Utara	2.548	1.298	1250
3	Kec. Dempo Utara	671	337	334
4	Kec. Dempo Selatan	558	285	273
5	Kec. Dempo tengah	527	278	249
	Total	6.444	3.364	3.080

alasan Saya memilih tabel Kotigensi Karna Tabel Kontigensi memiliki bentuk yang Pas Untuk mengisi Informasi / data yang Sudah ada

Alasan Saya Memilih diagram batang Karna lebih Cocok

alasan Saya tidak Memilih baris Kolom dan tabel distribusi Karna tidak Cocok

Alasan Saya tidak Memilih diagram garis dan diagram lingkaran Karna Diagram tersebut tidak Cocok dengan Informasi /data yang disa

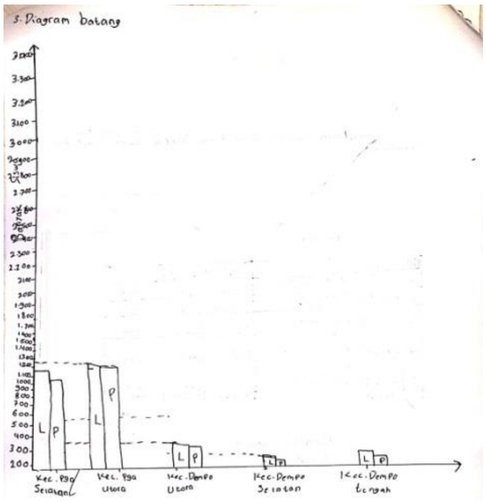


Figure 5 The Answer of One High Category Student

In Figure 5, the answer given by student "N" was not all correct. The student could answer the first indicator correctly using numbers and symbols to solve the problem, namely, finding the information from the question. In the second indicator, the student could not analyze information correctly. The student determined the type of contingency tables and bar charts correctly. However, in giving reasons for choosing a chart, this student only stated that it was more suitable without giving reasons why bar charts were more suitable for presenting the data provided.

In the third indicator, the student had not been able to interpret the results that had been done correctly. When presenting data as a contingency table, the student did not place the columns for the number and sex correctly. Sex should be put first, then the number. In the bar chart, the student needed to write down the x-axis and y-axis. In addition, the students needed to be more detailed in explaining why they did not choose other tables and charts. The reason for the answer was that other types of tables and charts were only suitable for describing data by giving detailed reasons for the answers given.

R: Why didn't you use other types of charts and tables?

N: I chose a contingency table and bar chart because other tables and charts were inappropriate for presenting data with available information.

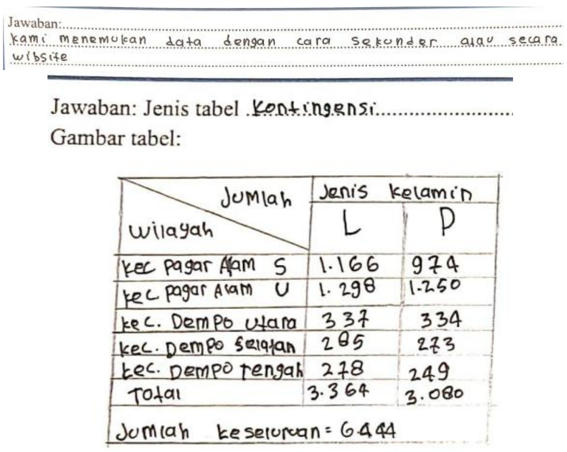
R: What conclusions can you draw from the tasks you have completed?

N: Ma'am, the conclusion is that the contingency table and bar chart can be used to present data on Pagar Alam Junior High School students in 2022 and 2023. Based on the data, Dempo Utara District has the fewest students, while Pagar Alam Utara District has the most. That is all from me, ma'am.

The student in the high category could answer the questions asked in the interview correctly. The student could also explain why the student chose the contingency table and bar chart. The student could also explain why they did not use other types of tables and diagrams because, as far as the student knows, the data used was not appropriate to be presented using other types of tables and diagrams. In addition, the student was proficient in concluding the questions given.

Students in the Medium Category

According to the test score, the student with the initials "G" is in the medium category. The student needed to meet all indicators regarding numeracy skills when working on test questions. The work results of student "G" are shown in Figure 6.


Jawaban: kami menemukan data dengan cara sekunder atau secara website

Jawaban: Jenis tabel kontingensi

Gambar tabel:

Wilayah \ Jumlah	Jenis kelamin L	P
kec pagar Alam S	1.166	974
kec pagar Alam U	1.298	1.250
kec. Dempo utara	337	334
kec. Dempo selatan	285	273
kec. Dempo tengah	278	249
Total	3.364	3.080
Jumlah keseluruhan = 6444		

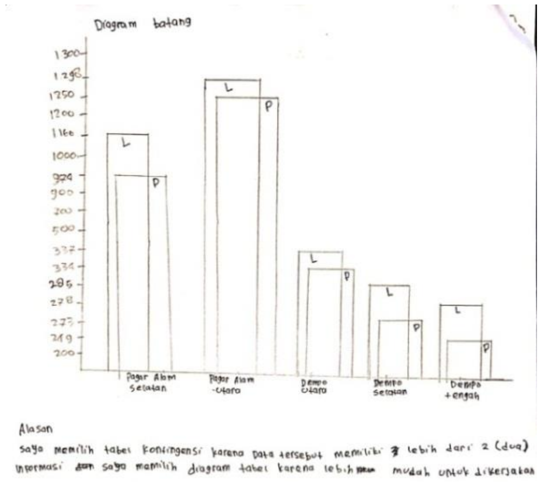


Figure 6. The Answer of One Medium Category Student

The student only mentioned a small part of the information found in response to the first indicator, using numbers and symbols to solve problems, namely finding information from questions. In the second indicator, the ability of the student to analyze information correctly had yet to be seen in the student. The students needed to be more precise in giving reasons for choosing the type of tables and charts, and they only wrote that because the bar chart was more suitable and did not provide more specific reasons.

In the third indicator, the student needed to be more precise in writing the position of the number in the column on the table and on the bar chart. The student also needed to write down the x-axis- and y-axis on the drawn bar chart. The student had yet to write down and explain why not to choose other tables and charts.

R: Why didn't you choose different types of tables and graphs?

G: I do not know either, ma'am, but a bar chart and contingency table are more suitable.

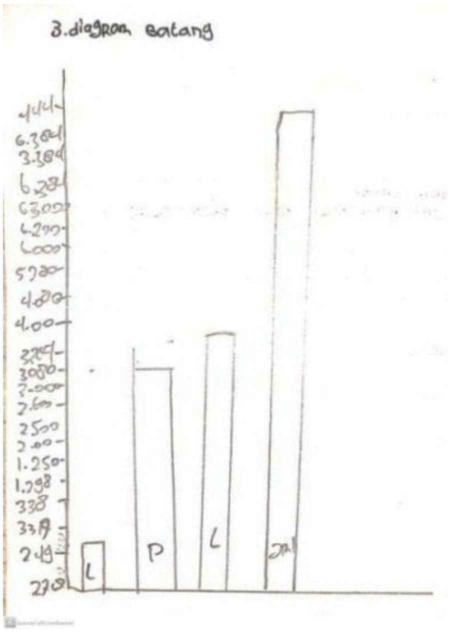
R: What is the conclusion of the problem?

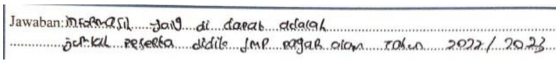
G: Ma'am, a contingency table and bar chart can be used to present data on Pagar Alam Junior High School students in 2022 and 2023. The information can be seen in Pagar Alam City on the Ministry of Education and Culture's website. That is all from me, ma'am.

Based on the interview findings that the researchers conducted with the student in the medium category, the student could state important information from the question but needed to state the information in the question entirely. The student could explain and give reasons for choosing the appropriate contingency table and bar chart and describe them. However, the student only believes that contingency tables and bar charts were more suitable for presenting data based on existing information, so the student could not give reasons not to choose other types of tables and charts. The question is very suitable for the student to draw their conclusions.

Students in the Low Category

According to their test score, the student with the initials "A" is in the low category. When working on test questions, the student needed to meet all indicators regarding their numeracy skills. The work results of student "A" are shown in Figure 7.





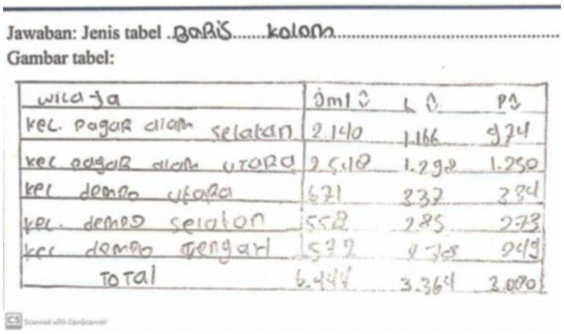


Figure 7 The Answer of One Low-Category Student

In the first indicator, using numbers and symbols to solve problems, namely finding information from questions, the student had yet to answer the questions fully and had not mentioned the questions in detail, only mentioning the title of the data without complete information. The student also needed help correctly analyzing the second indicator's information. The student could only correctly determine the appropriate type of chart but had yet to be able to determine the appropriate type of table correctly. The student described the table accurately but needed to be more precise when describing the chart accurately. In addition, the student had yet to write down and explain why not choose other tables and charts.

R: Why did you answer using a line chart?
AL: I do not know either, Mom; maybe this line chart is better for presenting data based on existing data? Also, describe the line chart type based on the provided data.
AL: I am confused, ma'am; because the data consists of men and women, it is difficult for me to conclude.

Based on the interview results, the low-category student revealed important information about the question, but the student needed to explain it in detail. The information only mentioned the number of Pagar Alam Junior High School students in 2022 and 2023, and it needed to explain in detail what this information means. While the student could identify and describe the different types of contingency tables, the student chose the correct chart. The students also could not give reasons why the students did not choose a different type of table and graph, only referring to the fact that the table might be more suitable for introducing information from existing data. The student was able to draw solid conclusions from the questions given.

Discussions

This research has produced numeracy-based teaching material for the data presentation topic in grade 7 that is valid, practical, and potentially affects students' numeracy skills. The validity of the teaching material is known from the average score given by the validator, which is 86.54. Based on the guidelines in Table 1, it is said that the teaching material developed is classified as valid. From the aspect of content, this teaching material is categorized as good with a score of 78.33; this means that the content in the teaching material is suitable for the data presentation topic. From the language and layout aspects, both are categorized as very good, with a score of 93.75 and 89.58, respectively. This means that from the aspect of language and layout, it followed the existing standards.

Even though the score of this teaching material is categorized as valid, the validators made suggestions for this teaching material to be revised. The suggestions made by the validators are shown in Table 4. The suggestions are given to improve learning objectives. Learning objectives were suggested to be written more fully so that what will be achieved becomes more focused. The teacher must consider learning objectives because they will impact the value of learning outcomes (Hansen, 2021), making them an essential component of learning (Li et al., 2021).

The next suggestion given by the validators is to add answers in the form of line charts. The answers in the teaching material are only in the form of bar charts. This suggestion needs to be accommodated for students' understanding of the types of data presentation charts to be more diverse.

At the One-to-One stage, the students could identify the types of tables and charts appropriate to the teaching material activity data based on the results produced for these activities. RK (students in the high category), AP (students in the medium category), and KN (students in the low category) said that the words used in the teaching material were easy to understand so that the students could use the teaching material for learning activities.

The next stage is the Small Group stage, which consists of two groups of three people each, like the One-to-One stage. The students were asked to read and complete activities based on the teaching material provided during the small group stage. The score of the questionnaire results was 90.48. This shows that the developed numeracy-based teaching material was included in the convenient category.

At the Field Test stage, the students had done all the activities in the teaching material, although some still needed to be completed. During the learning process, the teacher directed the learning. After the lesson, the students were asked to provide responses related to the teaching material used. Students’ responses to the teaching material stated that the teaching material is exciting because there are contexts that relate to the life around the students.

To get good learning outcomes, teachers are strongly encouraged to use contexts that are relevant to students (Reinke & Casto, 2022). Tasks/activities using contexts can help improve students' ability to complete contexts (Wijaya et al., 2018).

The average score of students in answering questions related to numeracy was 76.29, which is in the excellent category. There were 5 (16.1%) students belonged to the high category. This group was able to use numbers and symbols correctly, was able to analyze information correctly, but was not yet able to interpret the results correctly, still made mistakes in placing table columns, did not write the reasons for choosing the type of table correctly, and was able to conclude.

There are 15 (48.4%) students belong to the medium category. This group was able to use numbers and symbols to solve problems. It had been able to analyze information correctly. However, it could have been more precise in giving reasons for choosing the type of table (the answers given were not specific) and needed to be more precise in writing table data.

There are 11 (35.5%) students belong to the low group. This group had not wholly written down the information on the problem, could not analyze the information provided correctly, and could not explain the reasons for choosing the type of table or chart.

Based on the description of the research results, the teaching material that had been developed could help students present data well and choose the right type of data presentation. This teaching material is different from other teaching materials, which do not support students in choosing the type of data presentation. This teaching material can be used by students independently at home because the stages given in it provide opportunities for students to present data properly without teachers' guidance. Thus, this teaching material can be used for students with less daring characteristics to ask the teacher some problem-solving questions.

In all categories of student groups, one problem needed to be solved by students, namely the ability to give reasons for choosing the type of chart chosen. The students were asked to explain the reasons for choosing the chart type from the existing data. This finding indicates that the teaching material could have ideally provided information about the reasons for choosing the chart type for specific data. So, it needs to be a concern in revising the teaching material. Students' ability to present data in the form of charts indicates the level of knowledge of students (Diezmann, 2000).

This research needs to be developed further to deepen the study of the impact of using teaching materials on students' numeracy skills. It is necessary to develop more detailed activities in teaching materials to support students' ability to explain the reasons for choosing the chart type from the provided data.

Implication

The implication of the results of this research is to provide a reference for teachers in improving students' numeracy skills, especially in the data presentation topic using the resulting teaching materials. For students, this teaching material can be used independently to be used to train numeracy skills, especially in the data presentation topic. For other researchers, this research can be a reference for developing numeracy-based teaching materials on other topics.

Limitation

The limitation of this teaching material is that this teaching material needed to optimally provide space for students to give reasons in determining the type of data presentation selected. So that in the future, steps that provide opportunities for students to express reasons for choosing the type of data presentation can be added.

CONCLUSIONS

This research concluded that the data presentation teaching material developed in grade 7 was valid, with a score of 86.57 based on research findings conducted through preliminary, design, and formative studies. The teaching material was also included in the efficient category with a score of 90.4, and the field test results showed that the average student's work results were 76.29, which is in the excellent category.

The results of the numeracy test done by grade 7 students showed that the developed teaching material could affect numeracy skills. Five students were included in the high category, fifteen students were included in the medium category, and eleven students were included in the low category. The students said that the teaching material developed was fascinating because the questions were taken from real-world situations, the pictures were exciting, and it could help students understand the information in the data.

The researchers suggest that this teaching material can be used as a reference to help teachers teach the data presentation topic so that students understand the topic better. This teaching material can also be used as a reference in developing numeracy-based teaching materials in other mathematics topics. In addition, further research can be carried out with different skills, making this research a reference.

ACKNOWLEDGEMENT

The researchers would like to thank the school, especially the mathematics teacher and grade 7 students, who had given research permission and helped carry out this research. The researchers also thank the validators who helped validate the research instruments.

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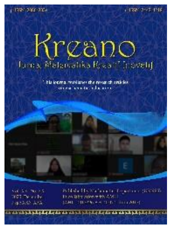
UNNES JOURNALS
Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 309-320



Intuitive Understanding of Kinesthetic Students in Solving Mathematics Problems with Realistic Mathematic Education Approach

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Abstract

Intuitive understanding is the ability to understand something without going through reasoning, so it is very important in solving math problems. One approach that can improve students' intuitive understanding is the Realistic Mathematic Education (RME) approach. However, not all students can use their intuitiveness in solving math problems. One of them is influenced by students' learning styles. For this reason, it is necessary to conduct research that aims to describe the intuitive understanding of students who have a kinesthetic learning style in solving math problems with the RME Approach. However, not all students can use their intuitiveness in solving math problems. One of them is influenced by students' learning styles. For this reason, it is necessary to conduct research that aims to describe the intuitive understanding of students who have kinesthetic learning styles in solving math problems with the RME Approach. The subjects of this research are students who have kinesthetic learning styles at SMKN 2 Tulungagung. The selection of research subjects is based on the results of the learning style questionnaire. Data collection methods with test questions, interviews, and documentation. Data analysis includes data reduction, data presentation, and conclusions. To test the validity of the data using method triangulation. Based on the research results, subject K1 leads to affirmatory intuition understanding, and subject K2 leads to anticipatory intuition understanding. It can be concluded that the intuitive understanding of kinesthetic students in solving opportunity problems has fulfilled the indicators of affirmatory intuition and anticipatory intuition. Furthermore, it is recommended to use the RME approach to improve students' intuitive understanding in solving math problems based on students' daily experiences or activities.

Keywords: Intuitif Understanding; Kinestetic Learning Style; RME.

Information of Article
Subject classification *97C30 Cognitive processes, learning theories (aspects of mathematics education)*
Submitted *21 January 2023*
Review Start *19 Februari 2023*
Initial Review Finish *9 May 2023*
Round 1 Finish *9 June 2023*
Round 2 Finish *20 June 2023*
Round 3 Finish *9 July 2023*
Accepted *10 July 2023*
Published *22 November 2023*
Similarity Check *6%*

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Abstrak

Pemahaman intuitif merupakan kemampuan memahami sesuatu tanpa melalui penalaran, sehingga sangat penting dalam menyelesaikan masalah matematika. Salah satu pendekatan yang dapat meningkatkan pemahaman intuitif siswa adalah pendekatan Realistic Mathematic Education (RME). Namun, tidak semua siswa dapat menggunakan intuisinya dalam menyelesaikan masalah matematika. Salah satunya dipengaruhi oleh gaya belajar siswa. Untuk itu perlu dilakukan penelitian yang bertujuan untuk mendeskripsikan pemahaman intuitif siswa yang memiliki gaya belajar kinestetik dalam menyelesaikan masalah matematika dengan Pendekatan RME. Namun, tidak semua siswa dapat menggunakan intuisinya dalam menyelesaikan masalah matematika. Salah satunya dipengaruhi oleh gaya belajar siswa. Untuk itu perlu dilakukan penelitian yang bertujuan untuk mendeskripsikan pemahaman intuitif siswa yang memiliki gaya belajar kinestetik dalam menyelesaikan masalah matematika dengan Pendekatan RME. Subyek penelitian ini adalah siswa yang memiliki gaya belajar kinestetik di SMKN 2 Tulungagung. Pemilihan subjek penelitian didasarkan pada hasil angket gaya belajar. Metode pengumpulan data dengan soal tes, wawancara, dan dokumentasi. Analisis data meliputi reduksi data, penyajian data, dan penarikan kesimpulan. Untuk menguji keabsahan data menggunakan triangulasi metode. Berdasarkan hasil penelitian, subjek K1 mengarah pada pemahaman intuisi afirmatif, dan subjek K2 mengarah pada pemahaman intuisi antisipatif. Dapat disimpulkan bahwa pemahaman intuitif siswa kinestetik dalam menyelesaikan masalah peluang telah memenuhi indikator intuisi afirmatif dan intuisi antisipatif. Selanjutnya disarankan untuk menggunakan pendekatan RME untuk meningkatkan pemahaman intuitif siswa dalam menyelesaikan masalah matematika berdasarkan pengalaman atau aktivitas siswa sehari-hari.

INTRODUCTION

One of the skills that students must go through in solving problems is the process of thinking analytically and using rational logic. The thinking process is followed by understanding, if someone understands and can explain something correctly, then that person can be said to understand or understand. Understanding is a way of drawing conclusions (Komariyah et al., 2018b). Comprehension is a person's ability to understand or comprehend something after something is known or remembered, including the ability to capture the meaning of a meaning that is studied or convert data presented in a certain form into another form. (Suendarti & Liberna, 2021).

Piaget views that knowledge needs to be formed and built by someone who wants to know and understand it. (Ardiansyah et al., 2022). However, not all math problems can be solved with analytical understanding, sometimes students must have estimates or conjectures related to answers that might be the solution to a problem without having to go through proof. This is called intuitive understanding (Usodo, 2012).

Byers & Herscovics (1997) said that intuitive understanding means understanding where students have not yet **reflected** on schemas and have not rationalize how they think about the problem. Intuitive understanding is the ability to understand something without going through reasoning. Intuitive understanding according to Polya is an understanding that can estimate the truth of something without hesitation, before analysing analytically. (Anggrayani et al., 2019). For this reason, intuitive understanding is very important in solving math problems. This is in accordance with Wuryanie et al., (2020) which states that if students' intuitive understanding is good, it will help students easily determine the solution to each problem faced. And vice versa, if students' intuitive understanding is not good, it will hinder the problem solving process.

Furthermore, intuitive skills are also very helpful in problem-solving situations (Hirza et al., 2014) Because when students face difficult situations, logical thinking is needed based on previous experiences or intuitions they have. So that in intuitive understanding students can solve math problems directly without using formal mathematical reasoning.

However, not all students have good intuitive understanding. It can be seen when researchers conducted observations and interviews with several students at SMKN 2 Tulungagung which showed that when students use routine procedures in solving math problems, these students take a long time and a lot of consideration in determining solutions. Meanwhile, students who do not use routine procedures are faster in solving math problems because consciously or unconsciously the chosen solution is based on previous experience. In addition, students who have good intuitive understanding will have different solutions from other students. (Sa'o et al., 2019).

In this study, intuitive understanding is categorized into 2 (two), namely affirmatory intuition and anticipatory intuition, this is in accordance with the definition of intuitive understanding. (Fischbein, 2002). Students' intuitive understanding in solving math problems is certainly different from one another. The ability to solve math problems is inseparable from the characteristics that students have. These characteristics that need to be considered during the teaching and learning process in the classroom are learning styles. A person's learning behavior must be different, there are those who like pictures, sounds and hands-on practice. A person's learning behavior must be different, there are those who like pictures, sounds and hands-on practice. Learning style is an approach method chosen and used by someone according to their needs in learning by adjusting the learning strategy needed (Ariandi, 2016). Connell includes: (1) visual learning style, a learning style that predominantly uses the sense of sight in absorbing information, (2) auditory learning style, a learning style that predominantly uses the sense of hearing in absorbing information, and (3) kinesthetic learning style, a learning style that predominantly uses movement in absorbing information.

In this study, the focus is on students who have a kinesthetic learning style. According to Deporter & Hernacki, students with kinesthetic learning styles have characteristics, namely: (1) speak slowly, (2) have difficulty remembering, (3) memorize by walking and seeing, (4) use fingers as a guide, (5) cannot sit still for a long time, (6) may have poor writing, (7) are physically oriented and move a lot, (8) want to do everything. (Tanamir & Dkk, 2020).

Students who have a kinesthetic learning style are unique. Generally, in absorbing information, they apply strategies and expressions that are characterized by physicality. Students with kinesthetic learning styles when given instructions in writing or verbally are often easily forgotten, because they tend to understand the task better if they try it directly, for that it is necessary to know the intuitive understanding of students who have kinesthetic learning styles in solving math problems.

The National Council of Teachers of Mathematics states that problem solving is a skill in high-level mathematical thinking to be able to develop thinking skills. (Ariandi, 2016). There are 4 (four) problem solving steps according to Polya, namely: (1) understanding the problem, (2) planning the solution, (3) implementing the solution plan, (4) re-examining the procedure and solution results.

O'Daffer (2008) said "porblem solving is a process by which an individual uses previously learned concepts, facts, and relationships, along with various reasoning skills and strategies, to answer a question or question about a situation", which means problem solving is a process carried out by an individual to answer questions about a situation by using previously learned concepts, facts, and relationships, as well as using various reasoning skills and strategies. (Riastini, P. N, 2017).

In this case it is important to know the learning style of students to make it easier for students to obtain information. However Kurniawati et al., (2022) I found that learning is still teacher-centered so without actively involving students. In addition, learning also lacks linking one material to another so that students cannot build their own knowledge. This causes students' intuitive thinking or understanding skills not to develop.

To improve students' intuitive understanding, teachers can use a learning approach. One of the learning approaches that can be used to improve students' mathematical intuition skills is the Realistic Mathematic Education (RME) approach.(Hirza et al., 2014). RME is an approach that is oriented towards realistic student reasoning by developing practical, logical, critical, and honest thinking patterns and is oriented towards mathematical reasoning in solving problems (Bunga et al., 2016).

Learning with RME provides realistic problems to students, because this learning is essentially a learning method that is actually very close to students' daily lives. That way students will be easier to lead to solve problems or solve math problems in accordance with their daily experiences (Susilowati, 2018).

The opinion of Hirza et al., (2014); Bunga et al., (2016); dan Susilowati, (2018) RME approach is one of the approaches that can be used in learning mathematics by involving students directly in solving mathematical problems based on students' previous experiences. (Dickinson & Hough, 2012). This supports the improvement of students' intuition in solving mathematical problems, so that teachers can use the RME approach to find out and improve students' intuitive understanding in solving mathematical problems.

There have been many studies related to understanding such as Suindayati et al., (2019) about layers of understanding based on pirie theory &Kieren; (Komariyah et al., 2018a) on concept understanding in problem solving. While research on intuitive understanding such as the results of research (Amir et al., 2020). Furthemore Hirza et al., (2014) examines the improvement of intuition skills with the RME approach; Purwaningsih et al., (2019) related to the characteristics of intuitive thinking based on cognitive style. Based on the results of the description, it is necessary to conduct research on students' intuitive understanding using the RME approach based on learning styles, so that teachers can improve students' understanding so that learning objectives are achieved by utilizing the intuitions that students have before.

METODE

The type of research used is descriptive research with a qualitative approach because it aims to describe intuitive understanding in solving math problems with the RME approach in terms of kinesthetic learning styles. The research subjects were students of class XI SMKN 2 Tulungagung who have kinesthetic learning style. The collection method is by test questions, interviews, and documentation. The data will be collected through interviews, while the purpose of the interview is to explore students' intuitive understanding. Furthermore, intuitive understanding is categorized into 2 (two), namely affirmatory intuition and anticipatory intuition. To test the validity of the data using triangulation method.

The stages in this study include (1) observation by conducting a preliminary study and studying the problem; (2) preparation of instruments; (3) instrument validation; (4) conducting classroom learning using the RME approach; (5) giving questions to find out the problem solving steps; (6) determining research subjects; (7) data analysis by conducting interviews with research subjects and comparing the results of student answers; (9) drawing conclusions as a result related to students' intuitive understanding in solving mathematical problems.

To test the validity of the data, researchers conducted a credibility test using method triangulation, namely comparing the data from the test results of mathematical ability questions with the results of interviews. Data analysis techniques include (1) data reduction, researchers take the results of the answers, (2) data presentation, clarify and identify student answers, (3) draw conclusions about students' intuitive understanding in solving problems with RME in terms of kinesthetic learning styles.

The indicators of intuitive understanding used in this study refer to the indicators proposed by Fischbein (Anjayani, 2017)found in Table 1.

Table 1. Indicators of Intuitive Understanding

A. Affirmative Intentions

Characteristics	Indicators
Direct	Students can immediately understand the meaning of the problem. Description: coherent answer, read the problem once, know what is known and asked.
Self-evident	Students can solve the solution without using empirical evidence. Description: statements that can be accepted directly (mentioning statistical formulas).
It must be intrinsically	Students can show the odds formula without proof. Description: use of the formula.
Tilt	Students can find the solution of the problem by following the arrangement of the known pattern from the beginning. Description: using theories that have been done or using experiences that have been done in solving opportunity problems. For example, using the formula.
Inspection	Students can conjecture the solution of the problem. Description: can write the formula and answer correctly, if one of the clues is known.

B. Anticipatory Intuition

Appears when striving to solve a problem	Students can find the solution to the problem, but it takes a long time. Description: read the problem more than once, knew what was known and asked but had to think for a while.
Using global ideas	Students can solve problems using other or different ways. Description: without using formulas, theorems, books, and definitions can use global ideas.
Contrary to popular belief	Students can conjecture the solution of the problem but in a different way or contrary to their conjecture (using feeling).

RESULTS AND DISCUSSION

Result

The research subjects were selected based on the instrument results of the learning style questionnaire. The results of the learning style questionnaire in class XI AKL 2 SMK Negeri 2 Tulungagung, out of 36 students in the class there are 2 students who are included in the kinesthetic learning style. From the list of students in class XI AKL 2, subjects were selected based on research that focuses on kinesthetic learning styles and obtained 2 students who have kinesthetic learning styles which are presented in Table 3.

Table 3. List of Research Subjects

No	Student Initials	Result	Subject Code
1	NSA	Kinesthetic	K1
2	NMZ	Kinesthetic	K2

Data Analysis of Subject K1 in Solving Opportunity Problems

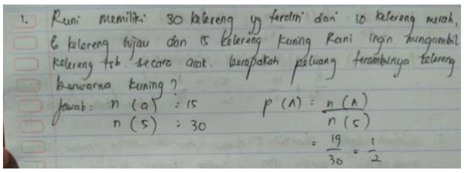

Figure 1. Subject K1's answer

Based on the written results of the problem solving carried out by subject K1, the subject can answer in detail and is equipped with a formula, this shows that he understands the meaning of the problem. The subject identifies the known and questionable information.

P: "Try to read question number 1, do you understand what it means??"
K1: "yes"
P: "What do you understand from the meaning of the question?"
K1: "Find the probability that a yellow marble is picked up"
P: "What information do you get from the problem?"
K1: "Value of all marbles and number of colored marbles"
P: "What did you do first after reading the question?"
K1: "Write down what is known, the number of all marbles owned, then the number of red, green, yellow marbles"

From the interview results, the subject was able to mention what was known and what was asked directly and in detail and could explain what he understood from the problem text. Thus, subject K1 was able to understand the problem directly and spontaneously took place after reading the problem.

Furthermore, at the stage of planning the problem based on the results of the test answers of subject K1, it was revealed that in the stage of planning the problem solving subject K1 immediately thought of using the formula for the probability of an event.

P: "Then what will you do next?"
K1: "Find the probability of the yellow marble being picked up, with a known value."
P: "How did you work on this problem? Was it by guessing, or trying out formulas, or how??"
K1: "I work according to the formula that I have learned"
P: "What formula did you use to solve the problem?"
K1: "Event probability formula"
P: "Are you sure that the formula can solve the problem?"
K1: "Yes, I'm sure"

From the interview results, subject K1 made a problem solving plan directly after understanding the meaning of the problem. Subjek langsung thought of applying the odds of occurrence formula, then according to the instructions solve the problem. Thus, subject K1 used the feeling that arose immediately when reading the problem in organizing the problem solving strategy using the odds of occurrence formula.

At the plan implementation stage, based on the written results carried out by subject K1, it can be revealed that subject K1 carries out the problem solving plan in accordance with the predetermined plan. Subject K1 can answer in detail and arranged according to the formula.

P:" After obtaining the formula for the probability of an event, what do you do next?"
K1: "Entering into the formula the value of the yellow marbles divided by the whole marbles, namely are $\frac{n(A)}{n(S)}$ *"*
P: "Please explain how you did it?"
K1: "First, I wrote down the known value, which is the total number of marbles owned then also the number of red, green, and yellow marbles. After that, I wrote down what was asked in the question, which was about the probability of the appearance of yellow marbles, then worked according to the probability formula, namely the

number of yellow marbles 15 divided by the total number of marbles of 30, so the result was ½".
P: "Have you done this problem before?"
K1: "Never been"

From the interview results, subject K1 can answer in detail the completion steps that have been done. The subject said he had never done a similar problem and the subject copied the steps from the material previously explained. Thus, it means that subject K1 utilizes his knowledge and experience that arises automatically, immediately, and spontaneously to solve problems. At the rechecking stage, based on the answer results, subject K1 did not recheck the answers that had been written.

P: "After finishing working on problem number 1, what did you do??"
K1: "I continue working on the next problem"
P: "Are you sure your answer is correct"
K1: "Yes, I'm sure"

From the results of the interview, subject K1 directly drew conclusions and said that he was sure of his answer.

Data Analysis of Subject K2 in Solving Opportunity Problems

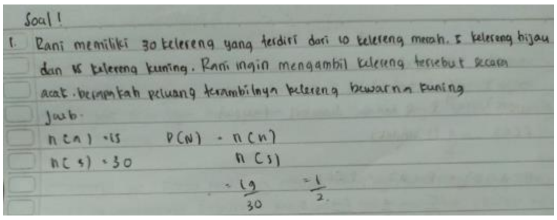

Figure 2. Subject K2's Answer Results

Based on the written results of the problem solving carried out by subject K2, the subject can answer in detail and is equipped with a formula, this shows that he understands the meaning of the problem. The subject identified the known and questionable information.

P : "Try to read question number 1, do you understand what it means?"
K2 : "Understood ma'am"
P : "What do you understand from the meaning of the question?"
K2 : "Searching for the yellow marble"
P : "What information did you get from the?"
K2 : "Number of red, green, yellow marbles"
P : "What was the first thing you did after reading the question?"
K2 : "Write down the known number of marbles Ms."

From the interview results, the subject was able to mention what was known and what was asked directly and in detail and could explain what he understood from the problem text. Thus, subject K2 was able to understand the problem directly and spontaneously took place after reading the problem.

At the stage of planning the problem based on the results of the test answers, subject K2 immediately thought of using the formula for the probability of an event.

P : "Then what will you do next?"
K2 : "Yes, looking for the probability of the yellow marble being picked up, ma'am."
P : "How did you work on this problem? Was it by guessing, or trying out formulas, or how?"
K2 : "Trying out formulas that have been learned"
P : "What formula did you use to solve the problem?"
K2 : "Formula for probability of occurrence Bu"
P : "Are you sure that the formula can solve the problem??"
K2 : " Sure ma'am"

From the interview results, subject K2 made a problem solving plan directly after understanding the meaning of the problem. The subject thought of trying out the formula for the probability of events that had been learned, then applying according to the instructions in the problem. Subject K2 stated that he was sure that the formula to be used was in accordance with the problem. Thus, subject K2 in organizing the problem solving strategy needed time to solve the problem using the probability of occurrence formula.

At the plan implementation stage, based on the written results carried out by subject K2, the problem solving plan is carried out in accordance with the predetermined plan. Subject K2 can answer in detail and is equipped with the formula.

P :" After obtaining the formula for the probability of an event, what do you do next??"
K2 :" Calculate it with the odds formula earlier ma'am "
P : "Please explain how you did it?"
K2 : "I wrote down the number of yellow marbles and all known marbles, then calculated according to the odds formula until I found the answer."
P : "Have you done this problem before?"
K2 : "Not yet ma'am"

From the interview results, subject K2 can answer well the steps of solving the problem in outline. The subject said he had never worked on a similar problem before, but the subject worked on this problem according to the formula he understood. Thus, subject K2 utilized his knowledge and experience to solve the problem.

P : "After finishing working on problem number 1, what did you do??"
K2 : "I double check ma'am"
P : "How do you double-check that?"
K2 : "Yes... making sure the amount I write is in accordance with the question until I find the answer"
P : "Are you sure your answer is correct?r"
K2 : "Sure ma'am"

At the re-examination stage, based on the results of the answer, it can be revealed that subject K2 re-examined the answers that had been written down. Subject K2 finished the calculations and problem solving that had been done using all the information and concepts of the existing material, then subject K2 drew conclusions directly. From the results of the interview, subject K2 did not immediately draw conclusions and said that he was sure of his answer. However, the subject crosschecks the solution steps that are done, until the subject feels confident with the final answer that has been obtained.

Discussion

Application of Realistic Mathematics Education (RME)

The research results from the application of RME are carried out in the classroom. The things that will be discussed in this section include planning, learning implementation, and observation. In the discussion, it will be associated with the Realistic Mathematics Education (RME) approach to improve the ability to solve opportunity problems.

In the planning stage, the researchers analyzed the boundaries of the opportunity material referring to the curriculum (K13) which had previously been consulted with the math teacher at school. The basic competencies conveyed are determining the chance of events and solving problems related to the chance of events. The learning process was designed following the steps in the RME approach. Then make a teacher observation sheet that refers to the application of the characteristics of the RME approach.

The second stage is the implementation of learning, the stages carried out include preliminary activities, core activities and closing activities. The learning steps are carried out in accordance with the steps contained in the RME approach, namely (1) understanding real problems with teachers providing real problems related to everyday life in mathematics learning and students understand these problems, (2) solving problems the teacher explains the situation and conditions of the problem by providing limited instructions / advice on certain parts that students do not understand, (3) comparing and discussing answers, namely the teacher provides time and opportunities for students to solve problems. comparing and discussing answers to questions in groups, and then comparing and discussing in class discussions, (4) concluding, namely the teacher directs students to draw conclusions about a procedure or concept with the teacher acting as a guide.

From the details of the steps in RME, the teacher acts as a facilitator or guide. This is in accordance with Laurens et al., (2018) dan Irdawati et al., (2019) that students can be actively involved in learning and the teacher is only a facilitator. So, classroom learning starts from things that are real for students, emphasizes skills, discusses, and collaborates, argues with classmates so that students can find their own and can finally solve mathematical problems either individually or in groups.

In the third stage, namely observation, observation is carried out by the observer to find out the teacher's activities, in this case the researcher, which is carried out during the learning process by looking at the suitability of the RME characteristics with reference to the lesson plans that have been prepared. The observer in this case is the XI grade math teacher at SMK Negeri 2 Tulungagung.

The results obtained with the RME approach are very significant. Students remain conducive, there are some students who find it difficult to solve math problems, after being given a direct picture using the media students understand. This is in line with (Fahmi et al., 2022) with the application of the (RME) approach makes it easier for students to solve the problems given.

In addition, the RME approach can improve students' real experience in learning. Because students are required to develop their thinking process in order to construct their own knowledge. (Widyasari &, 2021).

Results of Data Analysis of Intuitive Understanding of Students with Kinesthetic Learning Style (K1 and K2) in Solving Problems

At the stage of understanding the problem, subjects K1 and K2 did not experience difficulties in understanding the problem, so the subject suggested that it was easy to understand the information known in the problem. Affirmatory intuition is used by subject K1, this can be seen by the subject making a series of efforts to be able to understand the problem such as making auxiliary media in the form of illustrations, scribbles or certain sketches Anticipatory intuition is used by subject K2. This can be seen in the answer sheets of subjects K1 and K2 which are written clearly and in detail, the subject is believed to have understood the problem correctly because the subject can mention the known and questioned information properly and correctly and can explain the flow of problem solving coherently.

The results of the above analysis are relevant to previous research (Sari, N.I, 2017) which reveals the cognitive learning outcomes of students, which when students do practicum with the tools and materials and work procedures used, more and more senses will work, especially the sense of motion related to the kinesthetic learning style, so that the learning process becomes meaningful. Through practice by making auxiliary media, students who have a kinesthetic learning style will tend to be able to follow well because from the learning process when students observe, hear, and then carry out the steps of the procedure students will tend to involve their limbs which will encourage students to be more active in the learning process.

At the stage of planning problem solving, it can be concluded that subject K1 uses anticipatory intuition. This can be seen by the finding of subject K1 who argued that problem solving appeared shortly after the subject made a problem solving plan and tried to think about solving the problem. Subject K2 found the idea/problem solving plan at the time after reading the problem. Without using additional information other than in the problem, the subject believes that the solution idea obtained directly by the subject is correct and appropriate.

Nurrakhmi (2014) The subject used in making a problem-solving plan, the subject made a problem-solving plan based on the thoughts that appeared shortly after he tried to think about solving the problem.

At the stage of implementing the problem solving plan, subjects K1 and K2 worked according to the plan made. This happened because the subject felt that there were no obstacles at the implementation stage, so the subject worked according to the formula for the probability of events that had been studied previously. At the rechecking stage, subject K1 did not recheck his answers that had been written. Subject K1 uses affirmatory intuition, subject K1 directly draws conclusions without reviewing the formula, steps, or calculations he has done in accordance with the problem. Meanwhile, subject K2 did not directly draw conclusions and said that he was sure of his answer. However, the subject crosschecked the solution steps that were done, until the subject felt confident with the final answer that had been obtained.

Implication

Henceforth, teachers can use RME as an alternative learning approach to familiarize students in solving mathematical problems based on their experiences. With this, students can gradually use their intuition in understanding the mathematical concepts learned and can easily solve math problems. In addition, teachers can also use students who have kinesthetic learning styles in peer tutors in classroom learning.

Limitation

The limitation of this research is the number of subjects, namely two students and limited to intuitive understanding.

CONCLUSIONS

During the learning process in the classroom using the Realistic Mathematics Educaton (RME) approach, students remained conducive. There are some students who find it difficult to solve opportunity problems, after being given a direct picture using the media students understand. The Realistic Mathematics Education (RME) approach can be used as an alternative to choosing a mathematics learning approach to improve student understanding in solving mathematical problems.

Intuitive understanding in the stages of understanding the problem, making a problem solving plan, implementing a problem solving plan, and the process of checking back is included in the understanding aspect of Affirmatory Intuition, this is in accordance with the indicators of intuitive understanding in the affirmatory intuition category which shows students can immediately understand the meaning of the problem, students can show the opportunity formula, students can solve the problem according to the pattern known from the beginning, and students can write the formula and answer correctly. Intuitive understanding in the stage of understanding the problem and implementing the problem solving plan is included in the understanding aspect of Affirmatory Intuition, this is in accordance with the indicators of intuitive understanding in the affirmatory intuition category which shows students can immediately understand the meaning of the problem after reading the problem and students can solve the opportunity problem according to the pattern known from the beginning. At the stage of making a problem solving plan and the stage of checking back the subject is included in the aspect of understanding Anticipatory Intuition.

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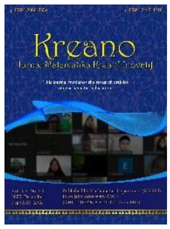
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 321-334



Spatial Reasoning of Middle School Students in View of Mathematics Anxiety

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Abstract

The low spatial reasoning ability and high mathematics anxiety of junior high school students is an interesting discussion to be studied in more depth to understand students' spatial reasoning abilities and mathematical anxiety. Therefore, this study aims to explore the spatial reasoning abilities of junior high school students in solving geometric problems in terms of students' math anxiety. The research method used is qualitative research with a case study type. Data were collected through written tests to explore spatial reasoning data, followed by task-based unstructured interviews and a Likert scale questionnaire to explore math anxiety data. Furthermore, the research data were analyzed by following the Miles and Huberman model, which consisted of data reduction (data reduction), data presentation (data display), and concluding (verification). The results showed that the average student's math anxiety was 2.294. Students' spatial reasoning abilities were dominated at a moderate level, namely 69.23%. The results also show that the students' spatial reasoning ability does not depend on the math anxiety category. The ability of spatial orientation is the ability most students master. Once the mathematical anxiety and spatial reasoning abilities of students are understood, it is intended that the teacher would take this into account while structuring geometry instruction in the classroom, which will foster the growth of students' spatial reasoning while simultaneously lowering the number of students' mathematical anxiety.

Keywords: Mathematics *Anxiety, Spatial Reasoning, Spatial Visualization, Mental Rotation, Spatial orientation*

Information of Article	
Subject classification	*97G10 Comprehensive works on geometry education*
Submitted	*24 February 2023*
Review Start	*27 February 2023*
Initial Review Finish	*11 March 2023*
Round 1 Finish	*11 March 2023*
Round 2 Finish	*11 May 2023*
Round 3 Finish	*29 May 2023*
Accepted	*30 May 2023*
Published	*24 November 2023*
Similarity Check	*6%*

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Abstrak

Rendahnya kemampuan penalaran spasial dan tingginya kecemasan matematika siswa SMP menjadi bahasan menarik untuk dikaji lebih mendalam supaya diperoleh pemahaman menyeluruh tentang kemampuan penalaran spasial dan kecemasan matematika siswa. Oleh karena itu penelitian ini bertujuan untuk mengeksplorasi kemampuan penalaran spasial siswa SMP dalam memecahkan masalah geometri ditinjau dari kecemasan matematika siswa. Adapun metode penelitian yang dilakukan adalah penelitian kualitatif dengan jenis studi kasus. Data dikumpulkan melalui tes tertulis untuk menggali data penalaran spasial dilanjutkan dengan wawancara tidak terstruktur berbasis tugas, dan angket skala likert untuk menggali data kecemasan matematika. Selanjutnya data penelitian dianalisis dengan mengikuti model Miles dan Huberman yang terdiri atas: reduksi data (data reduction), penyajian data (data display), dan penarikan kesimpulan (verification). Hasil penelitian menunjukkan bahwa rata-rata kecemasan matematika siswa yaitu 2,294. Kemampuan penalaran spasial siswa didominasi berada pada level sedang yakni 69,23%. Hasil penelitian juga menunjukkan bahwa kemampuan penalaran spasial siswa tidak bergantung pada kategori kecemasan matematika. Kemampuan orientasi spasial menjadi kemampuan yang paling banyak dikuasai siswa. Setelah kecemasan matematika dan kemampuan penalaran spasial siswa diketahui maka diharapkan dapat menjadi bahan pertimbangan guru dalam mendesain pembelajaran geometri di kelas yang dapat merangsang perkembangan penalaran spasial siswa, pun juga dapat mengurangi tingkat kecemasan matematika siswa.

INTRODUCTION

Spatial reasoning and geometry are two crucial things in child development. Spatial reasoning is a prerequisite for many occupations and is not simply important when learning geometry in a classroom (Ramful et al., 2017). Therefore, the ability of spatial reasoning is essential in life, but students still lack spatial reasoning abilities.

Spatial reasoning, spatial thinking, and spatial abilities are all phrases that are sometimes used interchangeably. According to some research, there is still no consensus on terminologies, definitions, or components (Uttal, Meadow, et al., 2013). Most mathematics education scholars use the term spatial reasoning (Battista et al., 2018; Fujita et al., 2020; Lowrie et al., 2016). According to Mulligan (2015), spatial reasoning is the ability to perceive and manage (mentally) the spatial features of things as well as the spatial connections between these items. Spatial visualization, mental rotation, and spatial orientation are frequent spatial reasoning components (Lowrie et al., 2019). Lowrie et al. (2019) define spatial visualization as the ability to mentally adjust or control an object's spatial features. Mental rotation is the rotation of 2D or 3D things in the mind (Mix & Cheng, 2012). The goal of spatial orientation is to comprehend and apply the connection that exists between the various locations of objects in space and one's own position (Clements, 1998). Students must take ownership of spatial reasoning because it is crucial for resolving issues in daily life. For instance, to park a car, locate a location using a map, establish oriented in a new place, arrange furniture in the home or office, understand a map's plan, etc. Through the provision of spatial tasks that accommodate all aspects of spatial reasoning, a person's spatial reasoning capacity can be determined. Spatial reasoning skills can also be developed (Uttal, Meadow, *et al*., 2013; Uttal, Miller, *et al*., 2013) through proper learning and can be practiced starting in the early years of school.

Several research findings indicate that students' spatial reasoning abilities are still low. Both at the National and International levels. At the elementary level, students' spatial skills are still relatively low (Kurnila et al., 2019; Wulandari, 2019). Likewise, the student's spatial ability in junior high school (Adam & Zulkarnaen, 2019; Akbar, 2019; Cahyati & Risalah, 2021; Leni et al., 2021) and students in high school (Afriyana & Mampouw, 2019; Imaniar et al., 2021; Novitasari et al., 2021; Perangin-angin & Khayroiyah, 2021; Rahmatulwahidah & Zubainur, 2017; Thohirudin et al., 2017). Low spatial abilities were also found in mathematics education students in Aceh (Daulay et al., 2021). At the international level, several studies have also shown that students' spatial abilities from school (Carr et al., 2018; Möhring et al., 2021; Sorby & Panther, 2020) to tertiary institutions are still low (Toptas & Karaca, 2017).

The low spatial ability of students both at the national and international levels has an impact on students' geometry abilities. In contrast, geometry is part of mathematics which further reinforces the perception that mathematics is imaged as a complex subject. Many factors cause students' learning achievement in mathematics is still low. Among them is the affective aspect. One of the affective aspects that can affect math achievement is math anxiety (Berliana & Adirakasiwi, 2021; Skagerlund et al., 2019). Math anxiety concerns mathematics situations (Carey et al., 2017). Furthermore, Zhang (2022) divides math anxiety into math anxiety in class, math anxiety when taking tests, math anxiety in problem-solving, and anxiety about the feeling of math as a whole. The aspects of math anxiety that are combined from various perspectives include social phobia (Lowe, 2018), disliking mathematics (Ashcraft, 2002; Wilson, 2018), physical symptoms (Harari et al., 2013; Lowe, 2018; Wilson, 2018), anxiety (Harari et al., 2013; Lowe, 2018), avoiding mathematics (Ashcraft, 2002; Wilson, 2018), and cognitive impairment (Lowe, 2018). Strong concentration and focus are required when performing tasks that call for spatial reasoning skill. Students who struggle with math anxiety may find it harder to focus and pay attention, which will ultimately affect their ability to use spatial reasoning.

The results of previous research indicate that the math anxiety experienced by junior high school students (Berliana & Adirakasiwi, 2021; Fadilah & Munandar, 2020; Prahmana et al., 2021; Utami & Warmi, 2019); high school students (Adhimah & Ekawati, 2020; Juliyanti & Pujiastuti, 2020; Khoirunnisa & Ulfah, 2021; Kusmaryono & Ulia, 2020; Nurjanah & Alyani, 2021; Supriatna & Zulkarnaen, 2019) and even university students (Prahmana et al., 2019; Purnomo & Loekmono, 2020) are in the high category. At the international level, math anxiety is a hot issue that researchers are also studying. Several studies report that students' math anxiety is still high (Mutlu, 2019; Orbach et al., 2019; Wang et al., 2020), including adults' math anxiety (Hart & Ganley, 2019).

The low spatial reasoning ability and high mathematics anxiety of junior high school students is an interesting discussion to be studied in more depth to understand students' spatial reasoning abilities and mathematical anxiety. Therefore, this proposed research aims to explore the spatial reasoning abilities of junior high school students in solving geometric problems in terms of students' math anxiety. The purpose of this study is to investigate students' spatial reasoning skills in relation to their level of mathematics anxiety, which will give a general summary of the traits of students' spatial reasoning skills. The features of spatial reasoning ability are predicted to influence mathematical skills in general and understanding of geometric concepts in particular. In addition, the urgency of this research can also provide an overview and knowledge for teachers in designing geometry learning designs that accommodate spatial reasoning abilities and minimize their math anxiety.

METHOD

This study used a qualitative approach with a single case design embedded case study design (Creswell, 2015). One of Yogyakarta's Muhammadiyah Middle Schools serves as the research site. Subjects were taken from class VIII students consisting of 55 students. Students initially took part in completing a Google form-based survey about their math anxiety. The 36 statements that make up the math anxiety questionnaire address three different types of math anxiety: learning mathematics, assessing mathematics, and social mathematics. Each type of math anxiety is composed of two statements that address different components of math anxiety, such as social fear, avoidance to mathematics, negative impressions of mathematics, physical symptoms, anxiety, and cognitive impairment. The results of the math anxiety survey were then processed using Microsoft Excel to be classified into three categories: high, medium, and low levels of math anxiety. Several students were taken at each level of math anxiety and then given a spatial reasoning ability test. Subject-taking at each level of mathematical anxiety was stopped until the data on the students' spatial reasoning ability was saturated.

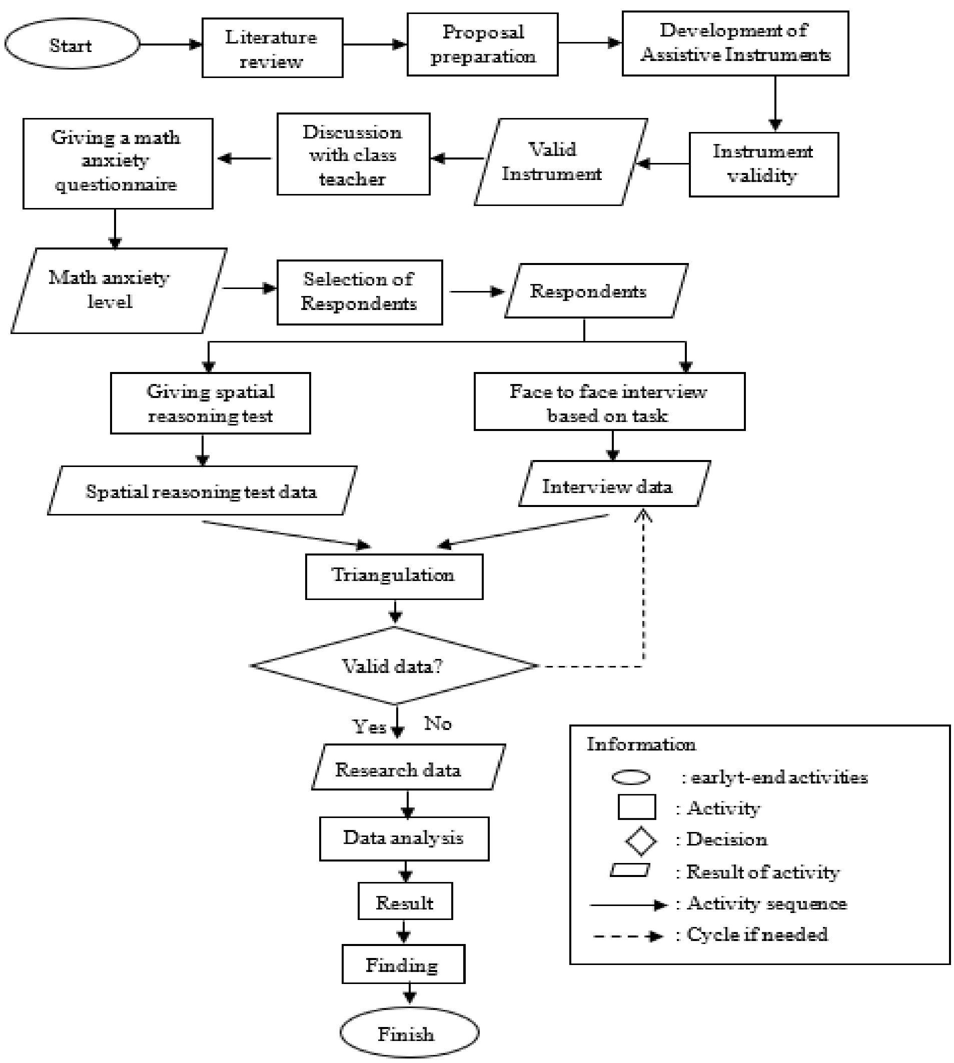

Figure 1. Research Stages

We used written tests, interviews, and questionnaires in addition to collecting data. The purpose of the written test is to retrieve student spatial reasoning ability. The spatial reasoning test utilizes the Ramful (2017) spatial reasoning test, which consists of 30 multiple-choice questions, ten drawn from each of the three elements of spatial reasoning: mental rotation, spatial orientation, and spatial visualization. Following that, several individuals were chosen for additional interviews to examine students' spatial reasoning data from a range of math anxiety levels and based on the math teacher's considerations. To uncover participants' spatial reasoning skills that had not been further examined from the findings of the spatial reasoning test, the interviews were done in an unstructured and face-to-face task-based way. Test the credibility of the data using source triangulation.

The procedure for analyzing qualitative research data follows the model of Miles and Huberman (Miles et al., 2014), which consists of data reduction, data display, and conclusion drawing. A reduction process was then carried out with qualitative data from data collection techniques using tests and interviews. The reduction process was obtained after the data was checked, extracted, and entered word for word, then coded independently by the researcher. Next, the researcher carried out the process of reviewing the validity of the data by triangulating the data. The results of data triangulation are then presented in the form of tables, diagrams, and or narratives as a basis for carrying out the process of concluding (verification). The stages of the research are presented in the following figure 1.

RESULTS AND DISCUSSION

Results

The data obtained in this study included math anxiety data obtained through closed and open questionnaires to explore the causes of students' math anxiety. The spatial reasoning data was obtained through a written test using multiple choices. Mathematics anxiety data is qualitative data, then converted to numeric and then processed with the help of Microsoft Excel to become a percentage. Qualitative data in the form of students' assessment of their math anxiety in the form of strongly agree, agree, disagree, and strongly disagree. Because the questionnaire statements include statements with negative values, the conversion becomes strongly agree (4), agree (3), disagree (2), and strongly disagree (1).

The math anxiety questionnaire was given online via Google form, and as many as 40 students participated in filling out the math anxiety questionnaire. The following Figure 2 describes student participation in filling out the math anxiety questionnaire.

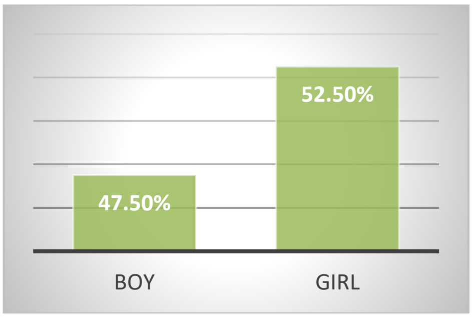

Figure 2. Percentage of student engagement

Most students stated that they had experienced math anxiety. Figure 3 shows the percentage of students who have experienced math anxiety.

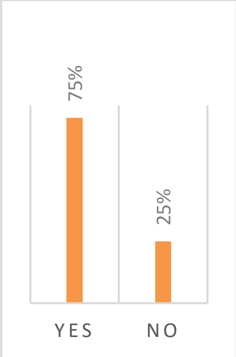

Figure 3. Percentage of students experiencing math anxiety

The math anxiety experienced by students started not only in the current class, but some students stated that they had experienced math anxiety since they were in elementary school. A complete description of the first-time student's experiences with math anxiety is presented in Figure 4.

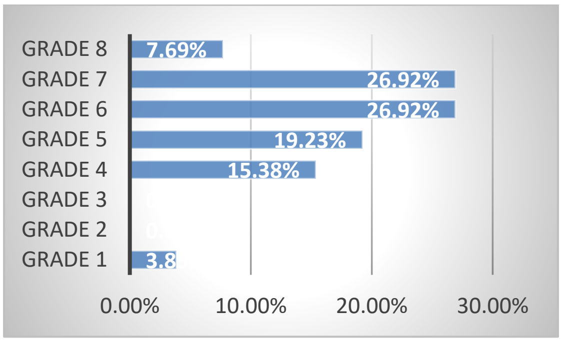

Figure 4. Students experienced math anxiety at first

In this research, math anxiety is divided into three types, namely: math anxiety in learning mathematics, evaluating mathematics, and social mathematics (Núñez-Peña et al., 2013; Recber et al., 2018; Semeraro et al., 2020; Skagerlund et al., 2019; Zakariya, 2018; Zhang, 2022). The results of data analysis of math anxiety on the type of learning mathematics are presented in Figure 5 below. Overall, the average math anxiety during learning mathematics is 2.49.

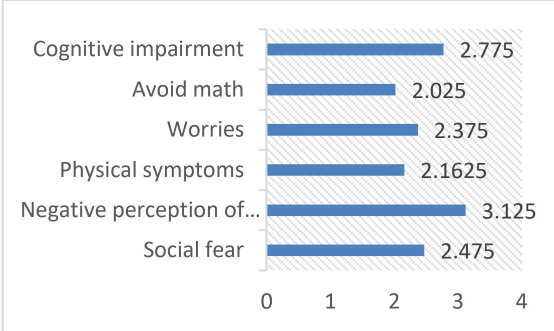

Figure 5. Average of students' math anxiety when learning mathematics

The second type, namely mathematical anxiety on the kind of mathematical evaluation presented in Figure 6 below. The overall average of students' anxiety during the mathematics evaluation was 2.56.

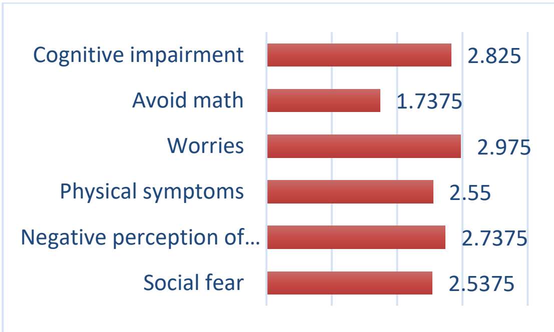

Figure 6. Average of students' math anxiety on mathematics evaluation

In the third type of math anxiety, social mathematics, the study results show that the average student anxiety varies, as shown in Figure 7 below. The average student's math anxiety on the social math aspect is 2.64.

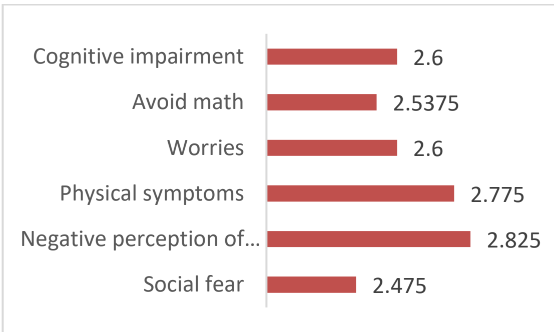

Figure 7. Average of students' math anxiety is social mathematics.

Based on the results of the research on math anxiety described above, it can be said that overall, the average student's math anxiety is 2.56 or still in the good category. The average mathematics anxiety in each type, namely mathematics anxiety in the type of mathematics learning, reached 2.49, the kind of mathematics evaluation showed average mathematics anxiety of 2.56 and the type of social mathematics earned 2.64. From this, it can be concluded that students are most anxious when dealing with situations involving mathematics in life or social mathematics.

In addition to the 3 types of math anxiety as described above, there are six aspects of math anxiety used in this study, namely social fear, negative perceptions of mathematics, physical symptoms, worry, avoiding mathematics, and cognitive impairment (Grezo & Ivan Sarmany-Schuller, 2018; Lowe, 2018). The results revealed that the average student's math anxiety was highest in the element of negative mathematical impressions, precisely 2.90.

Using descriptive statistics, subsequently divided the students' math anxiety data into three groups: high, medium, and low. From the calculation results, it was found that there were six students in the high category (15%), 27 students in the medium category (67.5%), and seven students in the low category (17.5%). Most students are in the category of moderate math anxiety. Furthermore, of the 40 students who filled out the math anxiety questionnaire, only 26 students had valid data for spatial reasoning abilities.

Of the 50 students who took the spatial reasoning test, after being reduced by considering the completeness of the answers to the 30 questions on the spatial reasoning test and their participation in filling out the math anxiety questionnaire, only 26 students met the criteria for further analysis. Of the 26 students, 10 were boys and the rest were girls. The data reduction results showed that there were 4 students in high math anxiety, 19 in the medium category, and 3 in the low category. As for the category of spatial reasoning ability, one student included high, 18 students had moderate, and the rest seven students included in the low category. Figure 8 below presents the categorization of students' spatial reasoning abilities.

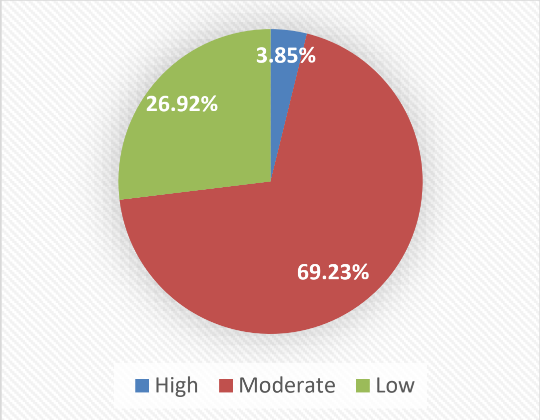

Figure 8. Category of students' spatial reasoning abilities

Figure 8 shows that the medium category still dominates students' spatial reasoning abilities. Of the 26 students, it turned out that only one student had high-category spatial reasoning abilities. The level of spatial reasoning ability is still dominated at the moderate level, namely 69.23%. As for gender, the average correct answers of male and female students on the spatial reasoning test showed nearly the same results. The average correct answer for male students was 12.2 and for female students was 12.75. This means that as many as 12-13 questions were answered correctly by the students.

Judging from the category of math anxiety, students' spatial reasoning abilities are not inversely proportional to the category of math anxiety. All students who are in the category of high math anxiety have the moderate category of spatial reasoning abilities. Students in the math anxiety medium category are at moderate and low spatial reasoning abilities. Students in the low math anxiety category have high, medium, and low spatial reasoning abilities. From this, it can be temporarily concluded that high math anxiety does not necessarily make students have low spatial reasoning abilities. More complete results can be seen in Figure 9 below.

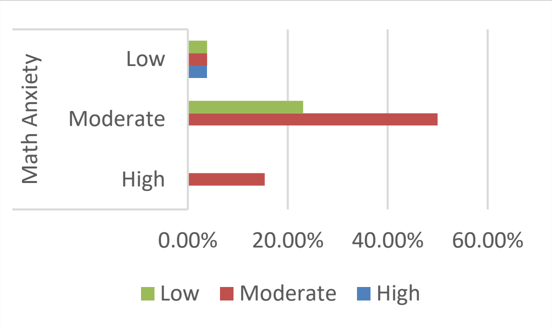

Figure 9. Distribution of spatial reasoning ability based on math anxiety category.

Three skills—spatial orientation, mental rotation, and spatial visualization—combine to form spatial reasoning. The findings of the spatial reasoning exam revealed that, on average, pupils correctly answered 6.77, or between 6-7 questions, regarding spatial orientation. While the second construction of spatial reasoning that students sufficiently master are the mental rotation type test, which is about 2-3 questions answered correctly or an average of 2.92. Likewise, the type of spatial visualization questions with an average correct answer of only 2.85 or 2-3 answered correctly.

Interviews were conducted for one day with a group interview design. Each participant was interviewed for about 30 minutes. The interviews result for triangulation data revealed that in carrying out spatial reasoning tests, students found it easier to do tests related to simple spatial orientations, such as determining the location of an object and showing pictures of objects from another person's point of view. But for this type of spatial orientation test regarding plans and the location of places on a map, most students are still confused about reading a map or finding the site of a place. For the type of spatial visualization questions, most students also still have difficulty doing it correctly. Students tend to imagine the pictures presented to find the answer. For mental rotation questions, some students tried to demonstrate rotating the question paper or making another image demonstration from the article. This method is considered quite effective in helping students find answers to questions. Some students also stated that they did not understand the terms used in the questions, so they answered them randomly.

Discussion

The results of the research described above show that mathematics anxiety and spatial reasoning abilities of students were vary. Many students' math anxiety is still at a moderate level, namely 72.5%. These results show that most eighth-grade students have moderate levels of math anxiety, which is consistent with their overall feeling of concern about mathematics. This data is in keeping with Yuliani's (2019) assertion that more than 85% of the class's junior high school students, who are in grades VII through IX, had moderate levels of math anxiety. In addition, these results also support the findings of Fadilah (2020) which states that most students have math anxiety at a sufficient level of the four levels used. Likewise, it supports the findings of Nurjanah (2021) which states that as many as 73.78% of students have math anxiety in the moderate category.

According to the forms of math anxiety examined in the study—including anxiety related to learning mathematics, anxiety related to mathematics evaluation, and anxiety related to social mathematics—students exhibit the highest anxiety when dealing with situations in life that require the use of mathematics. These findings different from Nurjanah's findings (2021) that junior high school students frequently experience high levels of anxiety when learning mathematics, despite the fact that Nurjanah places more emphasis on mathematics anxiety in online learning while this study's participants engage in offline learning. This is still pertinent considering how students are faring when they switch from online to offline schooling during the post-pandemic transition phase.

From the aspect of math anxiety which consists of six aspects, namely cognitive impairment, avoiding mathematics, anxiety, physical symptoms, negative perceptions of mathematics, and social fear, the research findings show that the highest average anxiety is on negative perception aspects of mathematics, namely 2.90, while the lowest average anxiety on the aspect of avoiding mathematics. This finding indicates that most respondents still have a negative perception of mathematics that triggers anxiety when interacting with mathematics both in class and in everyday life. Even so, the research data shows that respondents still want to interact with mathematics, as indicated by the average score of the aspect of avoiding mathematics, which is at the bottom.

The level of spatial reasoning ability of students yielded a variety of results. According to the findings, the level of students' spatial reasoning ability was dominated at the moderate level, namely 63.29%. These support the findings Fitriyani (2021; 2022) with junior high school students as subjects. The results of this study also inform that very few students have achieved high-level spatial reasoning abilities, namely, only one female student. This finding is in line with the results of Leni (2021) that students with a high spatial reasoning ability are still few in class. In addition, students with the female gender have high-level spatial reasoning abilities, thereby demonstrating that male and female pupils often exhibit different spatial thinking skills. This finding contradicts the notion that spatial reasoning abilities differ by gender (Newcombe, 2010). Furthermore, several research findings state that male students often have stronger spatial reasoning skills than female ones (Fitriyani & Kusumah, 2022; Maeda & Yoon, 2013; Moè et al., 2020; Ramful & Lowrie, 2015; Reilly & Neumann, 2013; Vander Heyden et al., 2016; Zancada-Menendez et al., 2016). In contrast, Newcombe (2010) stated that the spatial reasoning abilities of female students were better than male students. It is different from his findings (Fitriyani et al., 2021; Lowrie et al., 2016) which state that the spatial reasoning ability of the students are not gender-specific.

The research findings show that high math anxiety does not necessarily mean students have low spatial reasoning abilities. Students in the low math anxiety category have low spatial reasoning abilities. Even though the students were not worried, it turned out that their spatial reasoning abilities were still down. This is probably caused by other factors, such as understanding the concept of geometry and other factors because math anxiety does not bridge the relationship between spatial ability and math performance (Likhanov et al., 2017).

When considered from the perspective of the elements that make up the creation of spatial reasoning, including mental rotation, spatial visualization and spatial orientation, the research findings show that spatial orientation ability is an ability that most students have well. Students tend to be able to do well on spatial orientation tests. This finding supports the results of Leni's research (2021), which found that most students properly responded to the spatial orientation question of the spatial reasoning test. Likewise, it supports the findings of Latifah (2019), in which the research subjects experienced no difficulty working on the spatial orientation test.

The construction of spatial reasoning in the spatial visualization and mental rotation sections is almost the same as being mastered by the students. The results of the students' answers showed similar scores for the two constructions, but students' mental rotation abilities tended to be slightly better than spatial visualization abilities. Some students demonstrated by rotating the sheet of paper to imagine the object's final position after being rotated. This method is considered easier than rotating objects in mind. This follows the level of development of class VIII students who are just passing through the concrete operational stage and starting to enter the abstract operational stage (Ibda, 2015). Students find it easier to use physical objects in front of them to work on spatial reasoning questions.

The spatial visualization ability test is the most challenging test for students. Students have difficulty imagining objects to work mentally to process the information provided. This result is different from Pradana's findings (2019), where non-autistic students have superior concrete spatial visualization abilities while autistic students are more prominent in abstract spatial visualization abilities. Spatial visualization tests generally require students to be skilled at using their reasoning. Fitriyani's findings (2022) state that students view, observe, and pay attention to the things given as they complete their spatial visualization projects. The activity of imagining is a critical point for the successful completion of a spatial visualization task. Spatial visualization tasks include mentally imagining how an item will change (Ramful et al., 2015). Furthermore, To perform spatial visualization assignments, students employ visual methods (Fitriyani & Kusumah, 2022).

In completing the mental rotation task, students do more demonstrations or demonstrate the rotation of an image in completing the mental rotation test. Even though mental activity is still being carried out, students find it easier to find results by demonstrating concrete objects. This finding is different from the findings (Fitriyani & Kusumah, 2022), which state that students use things to mentally rotate as a justification for performing mental rotation exercises. In the spatial orientation task, it is easier for students to find the answer because this task is closer to the student's daily life. Students put themselves in the position of the object in the task given. This method follows Fitriyani's research (2022) results because Imagine viewpoints from different locations as part of spatial orientation (Lowrie et al., 2020).

Implication

Future study can focus on developing students' spatial reasoning skills while also lowering math anxiety among students by implementing learning models that assist the development of students' spatial reasoning skills.

Limitation

The subjects of this study were only students in one school with a qualitative approach, so the research results could not be generalized. In addition, online math anxiety data collection allows respondents not to take the questionnaire seriously. The study's findings on students' spatial reasoning skills dependent on their level of math anxiety are still in the exploratory stage.

CONCLUSION

The student's spatial reasoning skills varied, but they were moderately predominating—69.23%. The ability to visualize objects spatially is the one that students are least proficient in out of the three elements of spatial thinking. Students find it challenging to mentally construct objects to process the information given. The skill that many pupils have mastered the most is spatial orientation. Students find it simpler to complete activities requiring mental rotation with the aid of concrete object demonstrations. Additionally, class VIII students' mathematics anxiety dominated the moderate category with an average of 2.294 at maximum score of 4. The results of the study demonstrate that students' capacities for spatial reasoning are independent of their level of mathematics anxiety. Students who struggle with mathematics anxiety may not always be bad at spatial reasoning.

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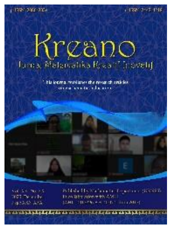
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 335-347



Development of Geometric Transformation E-Module Assisted by GeoGebra Software to Enhance Students' Mathematical Abilities during the COVID-19 Pandemic

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Abstract

During COVID-19 pandemic, teaching and learning was changed from face-to-face learning to online learning. There were many obstacles in learning mathematics by online-based learning. Such as geometric transformation, some material needs to be represented by a graphic or image, so that students will be easier to learn. This research was aimed to develop geometric transformation e-module assisted by GeoGebra software. The method of this research was used 4D-model developed by Thiagarajan, Semmel, and Semmel. The final draft of the e-module was validated by media and material experts. The results of this research showed that E-module was valid and feasible to be used in geometric transformation learning process. The feasibility of the module was proven by the average score of the validity test was 88% and 86.67%, that can be converted to very good criteria. A small group trial in using e-module obtained student responses is 82.30% which means that the e-module is good and easy to use. This study has implications in education, that can be used to enrich students' knowledge in the learning process of geometric transformation material, increasing student's activity, motivation, and learning outcomes.

Keywords: *E-module*, GeoGebra, *COVID-19 Pandemic*

Information of Article	
Subject classification	*97D40 Mathematics teaching methods and classroom techniques*
Submitted	*15 April 2023*
Review Start	*9 May 2023*
Initial Review Finish	*9 June 2023*
Round 1 Finish	*13 July 2023*
Round 2 Finish	*4 September 2023*
Round 3 Finish	*22 October 2023*
Accepted	*23 October 2023*
Published	*24 November 2023*
Similarity Check	*7%*

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Abstrak

Selama pandemi COVID-19, proses belajar mengajar diubah dari pembelajaran tatap muka menjadi pembelajaran daring. Banyak kendala dalam pembelajaran matematika dengan pembelajaran berbasis online. Seperti transformasi geometri, beberapa materi perlu direpresentasikan dengan grafik atau gambar, agar siswa lebih mudah mempelajarinya. Penelitian ini bertujuan untuk mengembangkan e-modul transformasi geometri berbantuan perangkat lunak GeoGebra*. Metode penelitian ini menggunakan model 4D yang dikembangkan oleh Thiagarajan,* Semmel, and Semmel*. Draf akhir e-modul divalidasi oleh ahli media dan materi. Hasil akhir dari penelitian ini menunjukkan bahwa E-modul sudah valid dan layak digunakan dalam proses pembelajaran transformasi geometri. Kelayakan modul dibuktikan dengan skor rata-rata uji validitas 88% dan 86,67% yang dapat dikonversi menjadi kriteria sangat baik. Uji coba kelompok kecil dalam penggunaan e-modul diperoleh respon siswa sebesar 82,30% yang berarti e-modul sudah baik dan mudah digunakan. Penelitian ini berimplikasi pada pendidikan, yaitu dapat digunakan untuk memperkaya pengetahuan siswa dalam proses pembelajaran materi transformasi geometri, meningkatkan aktivitas, motivasi, dan hasil belajar siswa.*

INTRODUCTION

During the COVID-19 pandemic, the implementation of the learning process at school has changed (Anggraini & Mahmudi, 2021; Mairing et al., 2021). It is carried out a great impact on the educational aspect. The most noticeable change was the implementation of learning that is held face-to-face in the classroom turns into virtual learning (Gillett-Swan, 2017). However, the virtual learning process has some problems practically (Curtis & Lawson, 2001; Handayani & Irawan, 2020). It also affects Students' mathematical abilities which are decreasing.

A student's mathematical ability refers to their proficiency and skills in various mathematical concepts and problem-solving within the field of mathematics (Al-Mutawah et al., 2019). Mathematical ability can be seen as the capacity to solve mathematical problems effectively. It involves the ability to perform mathematical tasks, solve quantitative problems, and understand mathematical concepts (Lerman, 2020). Student's Mathematical ability can be influenced by various factors such as self-efficacy, conceptual understanding, procedural knowledge, and problem-solving skills (Cano & Lomibao, 2023; Hoffman & Spatariu, 2008). Students' mathematical ability is really needed during the mathematics learning process (Setiawan et al., 2022). In Highly able mathematics students should independently demonstrate the ability to display mathematical thinking and have a keen awareness of mathematical structure, patterns, and relationships. They should also be able to reason logically, communicate mathematically, and make connections between mathematical concepts and other disciplines (Looi & Kadosh, 2016). However, mathematical ability of Indonesian students remains below standards as compared to those in other nations (Argina et al., 2017). Indonesian students' mathematical ability is only placed 72 out of 79 nations in the 2018 Program for International Student Assessment (PISA) survey, with an average score of 379, which is lower than that of Indonesia in 2015, which was ranked 63. The most recent educational innovations must be available to give students and instructors the chance to adequately complete off-class learning to overcome the generally poor mathematical ability of Indonesian students. To make learning more advanced and interesting, it becomes necessary to design a concept and process for information technology-based education. So, Indonesian student's mathematical abilities must be improved by implementing appropriate learning methods and developing learning media or module (Sutisna et al., 2018; Ulandari et al., 2019). During COVID-19 Pandemic, students cannot manage their learning well due to the limitations of the learning process. They tend to reduce their understanding of mathematical material. To prevent science and mathematics concepts from becoming dull, it is imperative that aspiring teachers learn to work with CTL as an antidote to knowledge transfer (Lestari et al., 2020; Mukwambo, 2016). So, teachers are forced to create various innovations to achieve effective learning. Teachers can use audio-visual media to engage students' interests, avoid giving too many tasks, and provide contextual assignments that are in accordance with the daily life of students.

In mathematics, audio-visual media is needed to visualize abstract material. The application of technology is a new alternative as a learning media in online learning (Muqorobin & Rozaq Rais, 2020). The use of technology provides great benefits in learning mathematics during online learning. One of the computer software that provides many benefits in learning mathematics is GeoGebra. GeoGebra is an online software that is available for free. It can be used as a mathematics learning media that can help teachers to design effective learning (Arbain & Shukor, 2015; Negara et al., 2022; Suryani et al., 2020) and assist lecturers in higher education (Sulistyawati & Rofiki, 2022). Based on Abramovich (2013), it can be used to learn geometry, algebra, and calculus at grade level and different ways of teaching.

Geometry is the oldest branch of mathematics. One of the topics in geometry is geometric transformation. The concept of geometry transformation is built by the concept of geometry and the concept of related interrelated functions (Malatjie & Machaba, 2019). Geometric transformations are very useful for developing spatial skills, reasoning skills in geometry, and strengthening proofs in the field of mathematics (Hanafi et al., 2017). Additionally, learning geometric transformations will provide many opportunities for developing visualization skills (Paradesa, 2016). Visualization aids play an important role in learning geometric transformations. By using display data visualization, it will be easier to see data that is hard to be viewed while thinking (Healy, 2018). For this reason, innovation in learning mathematics is needed using GeoGebra software. By GeoGebra, the teacher will be easier to demonstrate or visualize geometric transformation concepts, and it can also be used in the construction of mathematical concepts.

Based on the results of interviews with teachers at five schools in Sidoarjo and Surabaya city, during online learning, mathematics teachers in schools convey learning by providing explanations but giving little illustrations. They tend to use Microsoft PowerPoint as a learning media. In geometric transformation, students find it difficult to illustrate how the results of the transformation of geometric shapes. In addition, the mathematics learning process held at the SMK Manba'ul Ihsan Gresik during the pandemic was also limited to online learning using PowerPoint media and conventional textbooks. This affected students' mathematical abilities, especially in geometry transformation material, which was very low. In line with research conducted by Liono et al. (2021) and Medina Herrera et al. (2019), information was obtained that during online learning, students experienced difficulties in visualizing the transformed objects. Based on the information that many students have difficulty learning geometric transformation, teachers need to provide various alternatives to teaching geometric transformation, especially during online learning in the pandemic era. One of the alternatives is involving technology or the mathematics application in the learning process, so that, students can practice math in a fun and engaging way.

Many researchers have used GeoGebra to study geometry. Faizah and Astutik (2017)have developed student worksheets with the help of GeoGebra and linear programming material and are stated to provide effective results to improve students' understanding. Setiawati et al. (2021) produced student worksheets based on GeoGebra-assisted guided discovery on the material of plane that is valid, practical, and effective. In the research conducted by Andarwati and Hernawati (2013), the students' worksheet that has been developed was valid and effective to use in trigonometry. Suryani et al. (2020) developed a learning module on triangle material using GeoGebra so that it obtained a good practical result. Paradesa (2016) and Owusu et al. (2023) have developed teaching materials assisted by GeoGebra software in the transformation geometry course class. Most of the existing research developed worksheets for students in school and a module assisted by GeoGebra Software for university students in college. However, there are limited studies that integrate GeoGebra in the module that is specifically used by teachers as teaching material for transformation geometry in class. Even though, by integrating GeoGebra in the module it really helps students in understanding transformation geometry material.

Based on the explanation, GeoGebra has been widely used to help study various learning subjects. However, A few teachers in Gresik-East Java used GeoGebra to help improve students' understanding, especially on geometric transformation material. Moreover, the availability of innovative modules during online learning is very limited. Hence, this research aims to develop an e-module assisted by GeoGebra Software to improve students' understanding of geometric transformation which is expected to help visualize objects.

METHOD

This research is development research using the Four-D or Thiagarajan model, which consists of four steps, define, design, develop, and disseminate (Thiagarajan et al., 1974). The product of this research was an E-module of geometric transformation assisted by GeoGebra Software. The need analysis was carried out on the defining step by conducting the analysis of the student's characteristics, the curriculum applied, and formulating learning objectives. Then, the researchers compile the E-module design. In the designing step, Thiagarajan formulates 4 steps, i.e., criterion test construction, media selection, format selection, and initial design. Then, the product is tested for validity and effectiveness in the developing step. The product of this research was validated by two experts, a lecturer of the Educational Technology Department of the University of PGRI Adi Buana Surabaya and the teacher as the experts on the mathematics material. After the product was claimed as valid by the experts, then it limited trial was conducted on the eleven-grade students to test the effectiveness of the product.

The research instruments used are 1) an expert validation questionnaire. There are two types of expert validation questionnaires, content, and design validation; 2) students' response questionnaire; and 3) evaluation test sheet. It is the instrument used to measure student learning outcomes after carrying out learning using the e-module developed in this research.

This module will be tested on 15 students of class XI in SMK Manba'ul Ihsan Gresik. Most students at SMK Manba'ul

Ihsan Gresik live in Islamic boarding schools where access to technology is still minimal. Students can use information technology while at school. Whereas during a pandemic, they are required to study from home. They are not used to interacting with information technology, so that, it is very necessary to provide a module that contains steps for using the GeoGebra software so the geometry transformation material can be more easily understood.

The last step is analyzing the data obtained from the research. The researcher used quantitative and qualitative analysis. The data obtained is in the form of numbers, it will be analyzed using quantitative method, then converted into qualitative data that will be used to assess the product's validity. The evaluation criteria of the module are 1) valid based on the experts if the average of the average score is greater than 75%, 2) the average student response obtained is in the "Good" category, and 3) more than 80% of students in the class scored greater than 80.

RESULTS AND DISCUSSION

Results

The product of this development research is an e-module that meets the valid criteria. The development of the module in this research is assisted by GeoGebra software which aims to help provide clearer visuals to students in understanding the concept of geometric transformation. The results of this research can be described at each stage of the Four-D models (Thiagarajan et al., 1974) of research and development as follows.

Define

In the defining step, the need analysis was carried out by conducting the analysis of the student's characteristics, the curriculum applied, and formulating learning objectives. Based on the field survey, the students were less interested in learning mathematics during the online learning process. They found some difficulties to understand the concept of geometric transformation using pictures in the textbook. Some teachers experienced problems in providing clearer visuals to students during the online learning process. From that problem, the researcher took the initiative to provide an e-module assisted by GeoGebra software. The e-module developed in this study has been adapted to the applicable curriculum in the school, 2013 curriculum. Then, researchers formulate learning objectives that are in accordance with the curriculum.

The e-module was developed using an easy language, providing some images and links to the online GeoGebra to make it easier to the students to make clearer visuals about the geometric transformation. In this module, researchers provide some problems equipped with the steps to solve the problem using GeoGebra Software. It was developed using an interesting layout so that the students do not feel bored to learn mathematics.

Design

The second step of the research is designing the product. In the designing step, Thiagarajan formulates 4 steps, i.e., criterion test construction, media selection, format selection, and initial design. The researchers constructed a criterion test, as the first action to find out students' initial abilities, and as an evaluation tool after implementation of the product. In the media selection, the researchers selected and determined the right media for the presentation of subject matter that is adapted to curriculum analysis, analysis of student characteristics, and school facilities. The media selected in this research was the e-module developed using flipbook maker and it will be presented trough Zoom Meeting and Google Meet during online learning process. Then the format selection was adjusted to the characteristics of the students and the approach learning used student's centered learning. It will be developed by emphasizing on the interesting aspect and is easy to understand in accordance with the curriculum used in the school. The fourth step in this design stage is an initial design. In this step, the researcher made an initial design of the e-module and research instrument that will be used on the limited trial of the product. The research instrument developed in this step consists of 3 instruments, a validation questionnaire, a student response questionnaire, and an evaluation test. The following is a brief description of the design of the module.

The e-module developed consists of a cover, table of contents, instructions for using the module, mind map, geometric transformation materials, materials on GeoGebra software, evaluation tests, summaries, and a bibliography.

The cover of the module contains the title, author's name, and publisher. It was designed to reflect the contents of the module. It can be seen in Figure 1.

Figure 1. Module Cover

The table of contents in the module or teaching material serves as a listing of the order of the content of the material. The material is arranged based on the sub-chapters contained in the competency indicators along with the correct page order.

Instructions for use contain instructions for using the module. It is intended that students can use this module properly and correctly. In addition, a mind map is added which aims to show students what material will be studied. It is displayed in Figure 2 and Figure 3.

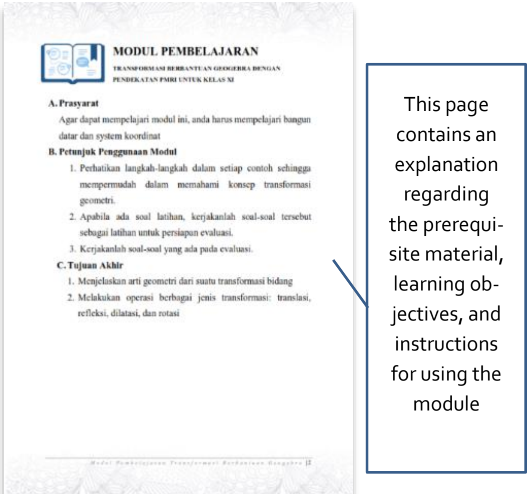

Figure 2. Instruction for Using e-Modul

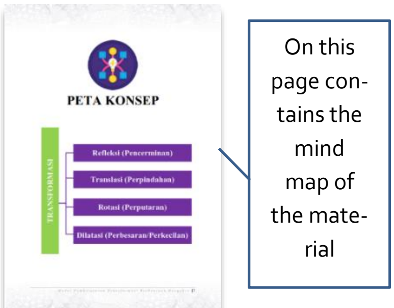

Figure 3. Mind Map of Geometric Transformation

The transformation material in the module contains reflection, translation, rotation, and dilatation sub-materials. In addition to presenting learning materials, this module also provides examples of the problem and the problem-solving of the geometric transformation material. It served the GeoGebra Software used in the material. It can be shown in Figure 4.

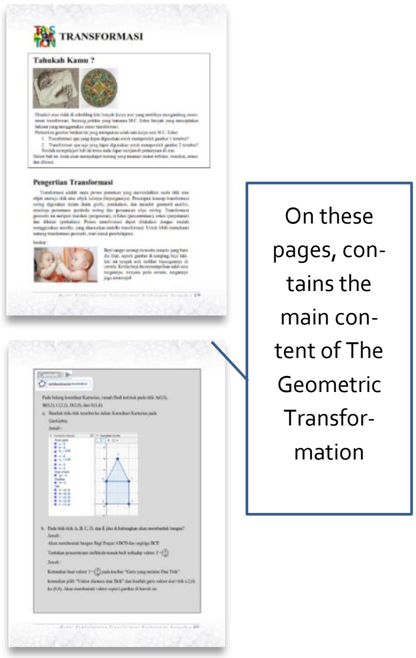

Figure 4. The Material of Geometric Transformation

The evaluation test provided in this module serves to assess student learning outcomes after using the module as teaching material in the learning process. Evaluation tests are prepared to refer to core competencies and basic competencies in the transformation material. Evaluation test problems are also equipped with an answer key so that students can study independently using this module. The evaluation test in this module contains 8 questions related to the transformation material.

The summary of a module is very important for students to remember the material that has been studied briefly, densely, and clearly. The initial design of this step is called draft 1 (see Figure 5).

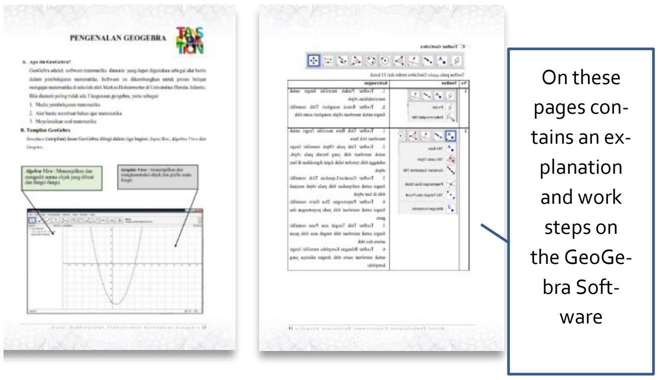

Figure 5. The Summary of the Material

Develop

In the development step, the e-module was compiled based on draft 1 which was designed on the previous step. The e-module produced at this step was limited to the initial product that still need to be validated and tested on students. The initial product in this stage is called draft 2.

The next step on this step was to validate draft 2 to the experts. Draft 2 of the E-module was validated by media and material experts. Module validation results were listed in Table 1.

Table 1. Recapitulation of Media Experts' Validation

Aspect	Indicator	Item
The e-module presentation	Design	4
	Text used in the e-module	5
	Image on the e-module	5
Media used on the e-module	Effectiveness of the media	4
	Instruction of use	4

Score: 22 | Average: 4.4 | Percentage: 88%

Based on Table 1, it can be known that the media validation got the percentage 88%. It can be categorized as "Very Good".

The results of material expert validation were listed in Table 2.

Table 2. Recapitulation of Material Experts' Validation

Aspect	Indicator	Item
Conformity of Material with SK and KD	Completeness of the material	5
	The breadth of the material	4
	The brief of the material	3
Material validity	Concept and definition accuracy	5
	Procedure and Algorithm accuracy	4
	accuracy of examples and questions	5

Score: 26 | Average: 4.33 | Percentage: 86,6%

Based on Table 2, it can be known that the material expert's validation got the percentage 86.67% which can be categorized as "Very Good".

From the experts, researchers got some advice to revise the e-module. The advice needs to be revised in the summary section and the example need to be arranged from simple to complex questions. Then it was revised based on the expert's advice, and draft 3 was obtained and ready to be tested in the trial class that consist of 15 students.

The next step is a limited trial to find out students' responses to using the e-module and the student's learning outcomes after the learning process using the e-module. The student's responses obtained from the trial class can be seen in Table 3.

Table 3. Recapitulation of Students' Response

Aspect	Score	Average	Percentage
Ease of use	66	4.40	88%
Presentation	62	4.13	82.6%
Quality of material	63	4.20	84%
Using contextual content	56	3.73	74.6%
Total Average			**82.30%**

Number of Students: 15

Based on Table 3, it can be known that the total average of the student's responses is 82.30% which means that the e-module is good and easy to use.

The students' learning outcomes after the learning process using the e-module can be seen in Figure 7.

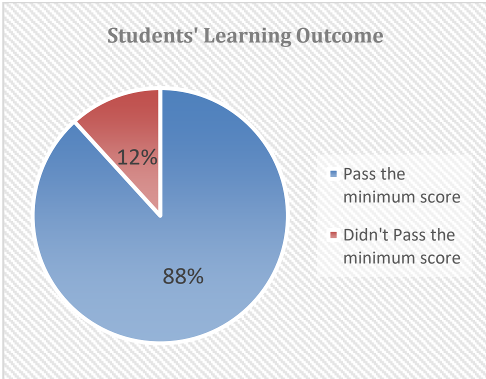

Figure 6. Students' Learning Outcomes

The information obtained from Figure 6 was that many students can be passed the minimum score for mathematics subjects set at school, namely 80. 13 students scored more than 80 and the rest (2 students) were still less than 80. They were tested after following the learning process using e-modules. It means that the e-module developed in this research is effective to use in the transformation geometry learning process.

Based on the limited trial of the e-module, researchers revised the e-module to be easier to use and understand by the students. Then, researchers got the final draft of the e-module. Hence, the e-module of geometric transformation developed in this research can be categorized as effective and ready to use in the class.

Disseminate

The e-module of geometric transformation that has been produced is not disseminated. It was handed over to the mathematics teachers at school to be implemented in the teaching and learning process.

Discussion

This research produced an e-module of

geometric transformation assisted by GeoGebra which is expected to help visualize objects in transformation geometry, so it can be increased the students' mathematical ability (Sutisna et al., 2018). In the developing step, the expert validation for the e-module was very good and worthy to be used. It also got good and easy-to-use categories, rated by the students in the limited trial class. The use of e-module assisted by GeoGebra software was acceptable in learning on online learning to help students understand and increase the student's mathematical ability in the subject of geometric transformation. By using GeoGebra Software, the e-module expect to have a positive influence on improving the students' mathematical ability and understanding of mathematical concepts in the learning process (Paradesa, 2016; Pratiwi, 2016; Setiawati et al., 2021).

GeoGebra Software used in the e-module, have some advantages on the learning process based on the results of the various studies, improved quality of learning, enhanced understanding, increased enjoyment during the learning process, improved knowledge retention, improved students' achievement, and support for mathematical proofs (Atteh & Asare, 2022; Birgin & Uzun Yazıcı, 2021; Celen, 2020; Shadaan & Leong, 2013; Tamam & Dasari, 2021). So, the use of GeoGebra software in this e-module is expected to help improve students' mathematical abilities.

The development of e-modules assisted by GeoGebra-assisted transformation geometry learning provides various benefits to enhance Students' mathematical ability. Firstly, E-module was designed for knowledge development and mastery competencies (Serevina et al., 2018). Lim et al. (2005) stated that the research on e-module creation showed that the e-module complies with student needs in terms of content, instructional techniques, teaching process, and software use. It in line with the statements of Sutisna et al., (2018) that Indonesian students' mathematical ability will be more advanced and interesting if it designed a a concept and process for information technology-based education.

Secondly, e-module can enhance teaching by supporting pedagogical content because it engages students to be more active by understanding the geometric transformation material on GeoGebra software (Yulando et al., 2019). This is in line with Logan et al. (2021) who stated that the development of e-module allows students to be better engaged with the content and more actively involved in their own learning. So, by using the e-module, Student's Mathematical ability can be increased based on various factors such as conceptual understanding, procedural knowledge, and problem-solving skills (Cano & Lomibao, 2023; Hoffman & Spatariu, 2008).

Thirdly, e-module development can help estimate course length, development time, and total course cost (Yaniawati et al., 2021). Fourthly, e-module development has been studied for its validity, practicality, and effectiveness (Nurhikmah et al., 2021). Based on the study done by (van der Merwe et al., 2020), shows that students are more prepared in the learning process and obtain better results by using the module. So that, students will be more engaged with the mathematics learning process, and it is expected that it can have a positive impact on students' mathematical abilities.

Besides the benefits of e-module developments, there are also some potential drawbacks to consider. One of the disadvantages is that e-module in e-learning requires the accessibility of technology. Additionally, some students may struggle with self-directed learning and require more guidance from the teachers (Kurniati et al., 2021). The last disadvantage of e-module development is that it may not be suitable for all types of content (Trilestari & Almunawaroh, 2021).

Based on the results of the analysis regarding the advantages and disadvantages of e-module development, it can be concluded that the development of e-modules assisted by the GeoGebra software provides benefits to the learning of geometric transformation, but in its use, teachers need to assist students to achieve the set learning objectives.

Implication

The development of an e-module assisted by GeoGebra software that has been carried out in this study has implications for education. E-modules of geometric transformation assisted by GeoGebra software can be used as enrichment material in the learning process of geometric transformation material, because by using this e-module students can get a more concrete representation of the results of transforming geometric objects through the GeoGebra software. GeoGebra facilitates the teaching and understanding of abstract transformation principles or concepts (Birgin & Acar, 2022; Birgin & Topuz, 2021; Dahal et al., 2019, 2022).

Students can learn geometric transformation material independently assisted by modules and GeoGebra software without the teacher's help, so that students' activity can be increased. Based on the student's responses to this research, the e-module is good and easy to use, so this can increase student learning motivation and can change the mindset of students who have considered mathematics as a difficult subject to be easier. Then, based on the test results, 86.67% of students passed the minimum score of the mathematics subject set on the SMK Manba'ul Ihsan Gresik. It means that the e-module can help to increase the student's mathematical abilities.

Limitation

The limitation in this research is the development of the module, which is limited to limited trials, so it is necessary to carry out wider dissemination to determine the effectiveness of using the module. Besides, the subject in this study was only in one school, then it could then be implemented for students in other schools.

The material that can be assisted with GeoGebra software is not only limited to transformation geometry, but can also be used in other relevant materials, such as linear programming, linear equations, inequalities, or algebra so that it can be developed into a wider material. The use of GeoGebra in mathematics learning is extremely beneficial for teachers in explaining mathematical material in the form of appealing visualization to develop students' understanding (Adelabu et al., 2022; Khansila et al., 2022; Munyaruhengeri et al., 2023; Nursyahidah & Albab, 2021; Suryani et al., 2020). Thus, students can be more helpful in studying mathematics material. In addition, this research can be continued to disseminate the developed e-module to see the effectiveness of its widespread use.

In the development process, the limitation of this study, the book was only validated by two validators, namely the media validator and the material validator. Furthermore, validation can also be carried out by linguists and graphic experts to obtain more accurate data in the assessment of the developed modules to understand the material.

CONCLUSION

To conclude, a geometric transformation e-module assisted by GeoGebra software was rated as valid by the media experts, the material experts, and the students. The geometric transformation e-module assisted by GeoGebra software can be declared effective to enhance the students' mathematical ability based on the results of limited trials in class. The e-module will be ready to implement for the students in senior high school. The development of an e-module assisted by the GeoGebra software provides benefits to the learning of transformational geometry, but in its use, teachers need to assist students to achieve the set learning objectives. Based on the result of the development of a geometric transformation e-module assisted by GeoGebra software can be continued research to disseminate the developed e-module to see the effectiveness of its widespread use in increasing the students' mathematical ability, especially in geometric transformation.

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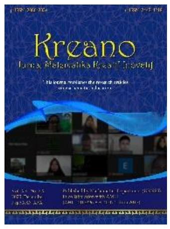
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 348-360



Development of Phet Simulation-Based Mathematics Logic E-Modules in Increasing Students' Mathematical Reasoning Ability

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Abstract

This research is represented through digital teaching with online learning simulations used by SMK teachers in learning mathematical logic that has not improved students' mathematical reasoning abilities. This study aims to describe the feasibility, attractiveness, and effectiveness of the PhET simulation-based mathematical logic e-module in improving students' mathematical reasoning abilities. This research method is the R and D. The research subjects were students of SMK Koperasi Pontianak majoring in Multimedia. Research data were collected using indirect communication techniques and measurements with data collection tools in the form of expert validation sheets, student and teacher response questionnaires, and test questions. Based on the results, it can be concluded that the e-module of mathematical logic with PhET simulation at the valid criterion, very interesting and effective. The results of this study can be implemented in the process of learning mathematical logic digitally through PhET simulation learning to improve students' mathematical reasoning abilities.

Keywords: *e-module;* mathematical *reasoning ability; PhET simulation.*

Information of Article

Subject classification	*97C30 Cognitive processes, learning theories (aspects of mathematics education)*
Submitted	*23 May 2023*
Review Start	*26 May 2023*
Initial Review Finish	*15 June 2023*
Round 1 Finish	*31 July 2023*
Round 2 Finish	*23 November 2023*
Accepted	*24 November 2023*
Published	*1 Desember 2023*
Similarity Check	*5%*

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Abstrak

Penelitian ini direpresentasikan melalui bahan ajar digital dengan simulasi pembelajaran online yang digunakan oleh guru SMK dalam pembelajaran logika matematika belum meningkatkan kemampuan penalaran matematis siswa. Penelitian ini bertujuan untuk mendeskripsikan kelayakan, kemenarikan dan keefektifan dari e-modul logika matematika berbasis PhET simulation dalam meningkatkan kemampuan penalaran matematis siswa. Metode penelitian ini adalah metode R and D. Subjek penelitian adalah siswa SMK Koperasi Pontianak tepatnya jurusan Multimedia. Data penelitian dikumpulkan menggunakan teknik komunikasi tidak langsung dan pengukuran dengan alat pengumpul data berupa lembar validasi ahli, angket respon siswa dan guru serta soal tes. Berdasarkan hasil penelitian dan pembahasan, dapat disimpulkan bahwa e-modul logika matematika dengan PhET simulation pada tingkat kriteria valid, sangat menarik dan efektif untuk menyelesaikan kesulitan pada siswa khususnya pada materi logika matematika. Hasil penelitian ini dapat diimplementasikan pada proses pembelajaran logika matematika secara digital serta melalui simulasi pembelajaran PhET simulation untuk lebih meningkatkan kemampuan penalaran matematis siswa.

INTRODUCTION

The reasoning process contributes in the form of the role of mathematics. Reasoning is a skill to solve a problem. Kusumawardani et al (2018), students in mathematics must be able to reason in solving problems through a logical process and critically, even in arithmetic. In addition, in social life the importance of the role of mathematics is very important. Mathematics can make people think logically, objectively, analytically, critically, and creatively when solving problems they face (Tsany et al., 2020). A discovery ability to find the truth is called reasoning. In terms, logic is a science that regulates human thought processes so that the results put forward can reach the truth (Suharto & Chotimah, 2018). Patterns of thinking logically, analytically, and critically are closely related to reasoning abilities (Putri et al., 2019). aspects of reasoning ability play an important role so that every student must have it as a criterion that must be developed to improve the mathematics learning process (Permatasari & Marlina, 2022). Reasoning ability plays an important role so that every student must have it as a criterion that must be developed to improve the mathematics learning process (Gustiadi et al., 2021; Konita et al., 2019). Mathematical reasoning ability is a form of thinking (Ariati & Juandi, 2022). Furthermore, Sumartini (2015) added that submitting conjectures and then compiling evidence and even manipulating the mathematical problems themselves so that students can draw conclusions correctly and precisely which can be obtained through mathematical reasoning. To do this, a reasoning process is needed through students' mathematical reasoning abilities.

Based on information obtained through interviews with one of the mathematics teachers at the SMK Koperasi Pontianak where he said that the mathematical reasoning abilities of students majoring in Multimedia were still low, especially in mathematical logic material. He also said that the teaching materials or media used in schools only use textbooks and student worksheets (LKS) which are usually sold on the market and have never used digital-based learning modules that can be accessed anywhere and anytime, resulting in a lack of independence in student learning making the students' mathematical reasoning abilities themselves does not develop as expected.

Truly, the low categorization was found in mathematical reasoning abilities, including: 1) research by Rismen et al (2020) found that students' reasoning and communication were not good, 2) Khainingsih (2020) concluded that low criteria were covered in students' mathematical reasoning abilities, and 3) Asdarina & Ridha (2020) concluded that the very low category is still fully held by reasoning abilities in working on questions equivalent to PISA. Some of these studies indicate that mathematical reasoning skills need to be improved. This is reinforced by the results of interviews with teachers at the SMK Koperasi Pontianak which have been described previously showing that the mathematical reasoning abilities of students in the Multimedia major are still low. One solution that can be offered is through the design of learning media in the form of e-modules where these teaching media can help students improve their mathematical reasoning abilities independently because they are not explored optimally while at school.

Anwar (Furqan et al., 2016) suggests that the learning material is systematically arranged and the content is interesting, even the use of methods and self-assessment in order to achieve the expected abilities. Herawati & Muhtadi (2018) stated that a module that contains text, images, or both is called an e-module, are simulated, and are suitable for use in learning in digital form. The module is a source of information that is empowered by students in order to add knowledge and motivation in learning in the learning process in class (Sa'diyah, 2021). In learning, the addition of simulation is suitable to be paired with e-modules.

Along with the development of the technological era and conditions for distance learning, modules in digital form (e-modules) are one of the learning media that can be used in learning which are present as an adaptive form of ordinary modules used during direct learning (Inanna et al., 2021). Currently, many electronic modules have been developed, or commonly known as e-modules (Seruni et al., 2019). Modules in digital form that run through a computer device so that they can display text, animation, images, and videos are known as e-modules. Advances in technology have also made it possible for e-modules to be displayed via smartphones (Laili et al., 2019). A theoretical presentation in digital form that can be used with electronic devices, namely Android and IOS, PCs, and even laptops is called an e-module (Saputra et al., 2022; Wulandari et al., 2021). In addition, one of the efforts to make modules more attractive to students is to make modules digitally with the aim of being used as an interactive learning media by inserting animations, images, audio and video (Sidiq & Ajuah, 2020; Widiana & Rosy, 2021). E-Modules will also be useful in increasing the effectiveness of free access to the learning process during (Fikri, 2022).

Based on the results of the analysis and summary of the use of variables from previous research scientific journal articles (Fikri, 2022; Herawati & Muhtadi, 2018b, 2018a; Saputra et al., 2022; Seruni et al., 2019; Sidiq & Ajuah, 2020; Widiana & Rosy, 2021), it turns out that the development of mathematical logic e-modules with PhET simulations that focus on students' mathematical reasoning abilities has never been carried out so that they become new variables and indicators in this study.

PhET Simulation is a simulation created by the University of Colorado where the scope includes physics, biology, chemistry, and mathematics for the benefit of class or individual learning. Emphasis on the relationship between phenomena in real life and the science that underlies them, support in the process of approaching interactively and constructively, providing feedback, and even providing a creative workspace called PhET Simulation (Finkelstein, 2006). The advantage possessed by PhET simulation is that it helps students understand the lessons conveyed (Saregar, 2016).

Several studies using PhET simulations include: 1) Fithriani et al (2016) found that students' thinking skills increased through PhET simulation media, (2) Mursalin (2013) concluded that minimizing student misconceptions was obtained from the PhET simulation model assisted by worksheets, (3) Wiravanjava (2017) stated that the results of research conducted through the application of PhET simulations showed a significant increase in critical thinking skills as student learning outcomes. Based on this research, the PhET simulation tool can be used as an alternative medium suitable for students to learn and support students' mathematical reasoning abilities.

Simulation allows students to participate in virtual worlds and application of their knowledge, thoughts, and skills. In addition, simulation can guide students to acquire their reasoning abilities and stimulate students' interest to be involved in discoveries requiring students' reasoning. The formation and transfer of skills in knowledge is focused on students to implement PhET simulations. According to Oktaviana & Prihatin (2020) concluded that by applying the PhET simulation-based mathematical logic practicum module has a positive effect on students' mathematical reasoning. In addition, Prihatin & Oktaviana (2021) added that students' mathematical reasoning increased after being given learning with PhET simulation-based mathematical logic practicum guide. Based on the previous explanation, this indicates that an electronic-based module (e-module) based on PhET simulation has not been applied to students with the aim of seeing their mathematical reasoning abilities in mathematical logic material.

This development study was carried out with reference to the research strategic plan on the topic of developing innovative learning-based teaching materials with products developed by mathematical logic e-modules based on PhET simulation. For this reason, researchers are trying to develop mathematical logic e-module based on PhET simulation of mathematical reasoning abilities.

METHOD

This research uses the type of R&D. Development is the process of making and testing products and their effectiveness (Sugiyono, 2016). The research design using the Borg and Gall model simulated in Figure 1.

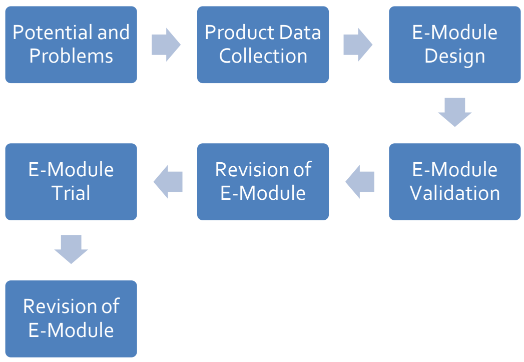

Figure 1. Borg and Gall Research Design

The stages in developing an e-module product based on PhET simulation are described as follows: (1) the potential and problem stages are carried out by exploring the problems encountered in the field. Researchers conducted pre-observations by conducting interviews and providing questionnaires related to the need for this product development; (2) the data collection stage is carried out by data collectors in product development. This data is collected from previous studies, how to use PhET simulation and materials in making e-modules; (3) the e-module design stage is the initial stage of designing e-modules before being tested in the field. Apart from that, instruments were also made; (4) the validator validates the e-module which then provides suggestions as a revision of the e-module itself. This step uses an expert validation sheet as a means of collecting data validated by the validator; (5) the next stage is field trials. Testing is done after the e-module is valid or feasible. Trials were conducted conduct an analysis of students' mathematical reasoning abilities as well as to see how practical the product is as a learning medium in class. If there are various deficiencies in the learning process at the product trial stage, revisions can be made to the product.

The subjects in this study were experts and students. The experts in question are media and material experts. Two lecturers in technology and information education are media experts. Media experts assess the appearance of the e-module regarding the composition of the content, coloring, layout, and images in the media. While the material experts are two mathematics education lecturers. Material experts provide an assessment of the presentation and suitability of the material in the product. Students are subjects in product trials. The student is a SMK student majoring in multimedia to be exact. Students who become product trials are taken based on the teacher's consideration by looking at the cognitive abilities of students.

The data collection technique used was measurement techniques and indirect communication. The data collection tools used were expert validation sheets, questionnaires, and mathematical reasoning ability test questions. The data analysis technique is to determine validity and attractiveness with the criteria of product validity and practicality and to calculate the effectiveness of e-module products based on PhET simulation with paired sample t-tests.

RESULTS AND DISCUSSION

Results

This research was conducted using ten (10) stages of the Borg and Gall development model that have been modified only up to the seventh step, namely product revision. This research develops a product that focuses on students' mathematical reasoning abilities in the form of mathematical logic e-modules with PhET simulations. The process that has been carried out in this study is the first, namely the potential and problems where researchers find a potential that students have, namely students in class XI of SMK Koperasi Pontianak have high creativity but the teaching materials are not yet available. Another potential is that with the existence of printed media whose contents are full of pictures and colors make students become interested in learning mathematics. Researchers conducted interviews and obtained results, the basic problems that occur in class XI students of SMK Koperasi Pontianak, in the process of learning mathematics, namely with students having difficulty understanding mathematical logic material, students are lazy to read textbooks, so they do not understand textbooks what they have thus requires simplification result in a better understanding of lessons. Another problem that arises is the limited learning media that can be explored in the mathematics learning process, and the teacher's learning methods lack the creativity of SMK Koperasi Pontianak students, resulting in a lack of enthusiasm for student learning.

The second is data/information collection where the researcher collects information in the form of supporting theory for the media to be made. Collect data that can be used as reference material or complementary data through interviews with teachers regarding problems in class, Front cover Back Cover

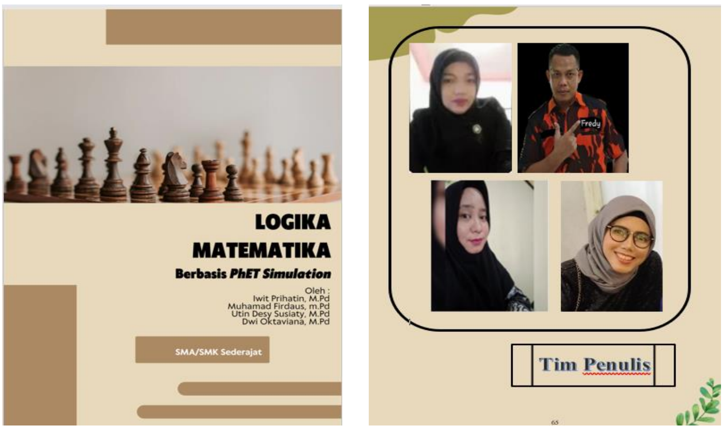

Figure 2. *Front and Back Covers of Mathematical Logic E-Modules with Phet Simulation*

as well as plans for making mathematical logic e-modules with PhET simulation. In addition, it was carried out by conducting a literature review of various existing literature. The researcher determined that the resulting learning media was in the form of learning media that refers to the 2013 curriculum, namely mathematical logic e-modules with PhET simulations. The results of observations along with interviews with mathematics teachers in schools related to learning mathematical logic turned out to be the difficulties experienced by students in solving mathematical logic problems.

The third is product design where the product design begins with designing the cover as well as the content design of the mathematical logic e-module with PhET simulation which will be developed. The cover view of the mathematical logic e-module with PhET simulation is shown in Figure 2.

The fourth is the design validation stage through three (3) people as validators with the aim of seeing the validity of the mathematical logic e-module product with the designed PhET simulation. The validation results are used to revise or improve the mathematical logic e-module with the PhET simulation that was developed prior to being tested. Table 1 shows the results of product validation.

Table 1. Validation Results

Research Instruments	Validators			Average	Criteria
	I	II	III		
Material	3,64	3,21	3,66	3,50	Valid
Mathematical logic e-module with PhET simulation	3,67	3,41	3,59	3,56	Valid
Questionnaire (Teacher)	3,68	3,20	3,68	3,52	Valid
Questionnaire (Students)	3,68	3,20	3,68	3,52	Valid
RPP	3,9	4	3,9	3,93	Valid
Evaluation or Posttest	3,76	3,76	3,52	3,68	Valid

Table 1 shows that the average score of the material expert validation results by the three validators is 3.50 with valid criteria, so further calculations can be continued which are obtained from the calculation results of the overall data validation of the material experts from the three validators. The validation results of the mathematical logic e-module with PhET simulations by the three validators have an average value of 3.56 with valid criteria obtained from the calculation results.

The average score of the validation results of the questionnaire (teacher) is 3.52 with valid criteria on the overall data of media experts from the three validators, the average score of the validation results of the questionnaire (students) is 3.52 with valid criteria, and the average score of the lesson plan validation results is 3.93 with valid criteria, then the result of completing the posttest questions is 3.68 with valid criteria.

After the initial product design has been validated by experts, deficiencies can be identified. These deficiencies will then be revised in the design, which is the fifth step, namely product revision.

After the mathematical logic e-module with PhET simulation has been validated and revised, the next step is to carry out the sixth step of product testing. The trial phase carried out by the researcher was a limited trial phase, because circumstances did not allow carrying out trials on a large scale. The school referred to in this study is the Pontianak Cooperative Vocational High School. This trial aims to see the attractiveness and effectiveness of the mathematical logic e-module with PhET simulation as a learning medium developed in mathematical logic material. The attractiveness of the limited product trial shown from the results of both teacher and student response questionnaires, then the effectiveness of the mathematical logic e-module with PhET simulation is shown from the results of the posttest.

The test results are as follows: (1) the interest in the mathematical logic e-module with the PhET simulation is shown from the results of the teacher and student response questionnaires. Then the results of the teacher and student response questionnaire to the mathematical logic e-module with PhET simulations.

Table 2. Results of the Teacher and Student Response Questionnaire

Respondents	Total Score	Percentage (%)	Criteria
Teacher	72	3,39	Very interesting
Student	49 (Highest)	3,92	Very interesting
	44 (Lowest)	3,52	Very interesting
	46,5 (Avg)	3,72	Very interesting

Table 2 shows that the results of the teacher's response questionnaire on the mathematical logic e-module with PhET simulation were 3.39 very interesting criteria, then the results of the student response questionnaire on the mathematical logic e-module with PhET simulation with an average score of 3.72 very interesting criteria.

Furthermore, (2) the effectiveness of the mathematical logic e-module with PhET simulation obtained from the results of the pretest and posttest completed by students of class XI SMK Koperasi Pontianak in accordance with students' mathematical reasoning abilities, which then carried out a hypothesis test with the aim of knowing that there was an increase in students' mathematical reasoning abilities after applying learning with mathematical logic e-modules with PhET simulations. The results of the pretest and posttest data of students' mathematical reasoning abilities were normally distributed.

Therefore, the requirements for normality in the paired sample t-test have been fulfilled. Then the hypothesis test was carried out and Sig. < 0.05 ($0.000 < 0.05$) which this means that there is a significant increase in students' mathematical reasoning abilities after applying learning with mathematical logic e-modules with PhET simulations. In the hypothesis test, it was found that there was an increase in students' mathematical reasoning abilities through the mathematical logic e-module with PhET simulation, it is said that the e-module is effective. The seventh step of the development process is product revision where the researcher makes the final revision obtained based on the test results data, resulting in the final product.

Discussion

If the learning source attracts the respondent to read and is delivered in a very interesting and varied way, it will make the respondent more interested and motivated and will develop his creativity and providing an understanding of the material to be received is an opportunity given to respondents. The development of learning media in this study, namely e-modules of mathematical logic with PhET simulations focused on students' mathematical reasoning abilities. Compulsory learning material studied by students at each level of the education unit is mathematics. Mathematics lessons are a systematization of logic, so that it can be said that logic is a category of pure mathematics (Prihatin et al., 2022). A science that conveys coherent conclusions and specifically develops the use of mathematical methods and uses special symbols so that a person may avoid multiple meanings in the use of everyday language is called symbolic logic (Rahmawati et al., 2021).

The results obtained from this development research are a mathematical logic e-module with PhET simulation in mathematical logic material for class XI SMK students that is valid, interesting, and effective. The results of the validity assessment of the three validators in the mathematical logic e-module with PhET simulation obtained 3.56. Based on the results of the attractiveness of the mathematical logic e-module with PhET simulation, teacher, and student response questionnaires respectively 3.39 and 3.72. The effectiveness of students' mathematical reasoning abilities through hypothesis testing with the t test, there is a significant increase in students' mathematical reasoning abilities after getting learning with the e-module of mathematical logic with PhET simulation so that it is categorized as effective.

The process of developing mathematical logic e-modules with PhET simulation in this study uses the Borg and Gall research design developed by Sugiyono (2016) which has stages namely identifying potentials and problems, conducting data collection, making product designs, validating designs, revising designs, testing products, revising products, testing product usage, revising products, and mass-producing. The potential and problem stage aims to collect a problem based on facts in the field. The data collection stage is collecting various information obtained as material for planning a particular product in the hope of overcoming the problem.

The results of collecting information obtained from interviews and observations are an important reference and foundation in making mathematical logic e-modules with PhET simulation in mathematical logic material, so that it can assist teachers in explaining mathematical logic material, as well as being an alternative of learning resources in the teaching and learning process with the aim of students not feeling bored during the learning process. The design validation stage is a process of conducting an assessment to see whether a rational product design will be effective or not in terms of material and media. The revision stage was carried out to find out the advantages and disadvantages of the product being designed. This product trial phase aims to obtain information whether the mathematical logic e-module with PhET simulation is effective. The product revision stage aims to improve the suggestions given by students. The usage trial phase aims to obtain information whether the mathematical logic e-module with PhET simulation is effective or not. The product revision stage is carried out to find out the weaknesses and deficiencies of the product designed and revised based on the validator's suggestions and comments. The mass production stage aims to determine whether the product that has been developed is effective or not. However, in this study it did not reach the mass production step due to time and cost constraints and this research was only intended to solve the problems that existed at the Pontianak Cooperative Vocational High School, so it only reached the seven step stage.

The development in this study focused on e-modules based on PhET simulations. The development process is the e-module that has been designed, while for PhET the simulation uses a virtual laboratory application, namely Physics Education Technology (PhET) simulation (Saregar, 2016). This simulation media was developed by Katherin Perkins et al from the University of Colorado, United States. This PhET simulation is made in Java or Flash so that it can be run directly from a website using a standard web browser (Rizaldi et al., 2020).

Borg and Gall's design has the objective of knowing the validity, attractiveness, and effectiveness of mathematical logic e-modules with PhET simulations. This is in line with Nieeven's opinion Mustaming et al (2015) who said that the quality of learning tools is based on criteria which include three aspects, namely: validity, practicality, and effectiveness.

Mathematical logic e-modules with PhET simulation must first pass validity so that they can be tested on a limited basis through the results of validation by the validator, then the attractiveness and effectiveness are determined based on the results of the response questionnaire and the results of the pretest and posttest. The validity of the mathematical logic e-module with PhET simulation was obtained from the validation results by the three validators. E-module mathematical logic with PhET simulation is declared valid with an average validity score of 3.56. The results of the validation are in the form of comments and suggestions on the mathematical logic e-module with the PhET simulation designed and research instruments. Before being tested on a limited basis the mathematical logic e-module with PhET simulation had to go through the first stage of revision is carried out based on the validation results, comments, and suggestions from the validator.

After completing validation, revising the product based on input and suggestions by media and material experts is the next step that must be carried out. Furthermore, conducting product trials, product trials were carried out to determine the attractiveness and effectiveness of the mathematical logic e-module with the developed PhET simulation. To find out effectiveness and interest can be seen from the results of trials using the product through the results of student and teacher response questionnaires, as well as the results of the pretest and posttest. The researcher gave student response questionnaires and pretest and posttest questions directly to students, which students had to do in the trial class, limited to the third meeting.

The provision of materials and questionnaires was carried out face-to-face to each Pontianak Cooperative Vocational School student. Questionnaires are distributed directly and must be done by students within a specified time limit. Closed questionnaire is the instrument in this study. Closed questionnaires are questionnaires that have provided alternative answers; thus the respondents' answers are in accordance with the limits of the answers given.

In accordance with the results of the student response questionnaire given in the limited trial class, which was distributed directly and worked on by students, the average practicality index percentage was obtained at 3.72 with very attractive criteria while the attractiveness index results from the teacher's response questionnaire were 3.39 with the criteria very interesting. Obtain the results from the teacher and student response questionnaire, the mathematical logic e-module with PhET simulation can be said to be very attractive to teachers and students. There are differences in criteria between teachers and students based on teachers who do not directly apply the mathematical logic e-module with PhET simulation but are carried out by researchers. This research is in line with the results of research by (Kartika, Sanapiah, & Julaingkary, 2017; Kartika, Sanapiah, & Juliangkary, 2017) who argued that the existence of a mathematical logic learning module for students greatly assists teachers in carrying out their learning activities, because the modules developed are usually adapted to the characteristics of the students themselves and the modules developed are appropriate for use in the learning process at school.

The presentation of the material in the mathematical logic e-module with PhET simulations is delivered in a clear and interesting way because it is equipped with appropriate pictures and colors. The mathematical logic e-module with PhET simulation in this study is of medium size and can be taken anywhere so that it is more practical to study anywhere, anytime and can assist students in independent learning because it can be accessed on their respective devices. This is because the students' response to the mathematical logic e-module with PhET simulation was very satisfying because students feel they understand the material contained in the mathematical logic e-module with PhET simulation more practically and it is more practical to learn anywhere and anytime.

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Based on the results of the pretest and posttest obtained during the limited trial, it showed that students' mathematical reasoning abilities increased more after using the mathematical logic module with PhET simulation. Referring to this, it is obtained that the e-module of mathematical logic with PhET simulation on mathematical logic material students understand the essence of the material presented and can complete the mathematical logic material well. The results of this study are directly proportional to the research conducted by Herawati & Muhtadi (2018) where it was found that the application and use of e-modules are generally categorized as proper and receive positive responses from students. There is a difference between the test results before using the e-module and the test results after using the e-module. Furthermore, research conducted by Sa'diyah (2021) found that digital flipbook-based e-modules are included in the category of valid and theoretically feasible.

Implication

The implications of this research so that it can become a point of view for future readers and researchers include: (1) the mathematical logic e-module with PhET simulation developed in this study can be continued by other researchers up to the tenth step, namely mass production on a wider scale; (2) the mathematical logic e-module with PhET simulation that is being developed still needs to be refined with further trials up to the tenth step so that the quality of the mathematical logic E-module with PhET simulation is truly tested in terms of its utilization; (3) before developing a product, look for as many references as possible related to the product to be developed.

Limitation

Limitations in conducting research include this research not being continued until the last stage, namely the dissemination stage. This is due to inadequate time and finances. In addition, researchers also do not master design other than using flip book applications, so researchers design e-modules only using flip book applications, both in terms of cover, title and even content. Furthermore, in this study, the researcher only examined one school and had not researched all schools or one area.

CONCLUSION

In connection with the results of the presentation related to the research and discussion, the conclusions that can be drawn are developments mathematical logic e-modules with PhET simulation in mathematical logic materials for class XI students of the SMK Koperasi Pontianak using The Borg and Gall model development plan consists of seven (7) steps, namely: finding potentials and problems, collecting data, conducting product designs, validating designs, revising designs, testing products, and revising the final product. The results of the formulation of the sub-problems that have been determined are as follows: (1) the results of the analysis of the three validators' validation sheet on mathematical logic e-modules with PhET simulations at the validity level with valid criteria, then the mathematical logic e-modules with PhET simulation can be used or can be tested; (2) the level of attractiveness with very interesting criteria and student responses with very interesting criteria. based on the analysis of filling out the questionnaire by the teacher and students, the e-module of mathematical logic with PhET simulation can be said to be attractive to teachers and students; (3) based on pretest and posttest analysis that has been completed by students in the limited trial stage, it is found that learning with mathematical logic e-modules with PhET simulation in class XI students of SMK Koperasi Pontianak can improve students' mathematical reasoning abilities, it can be concluded that logic e-modules mathematics with PhET simulation which was developed effectively to solve difficulties in class XI students of the SMK Koperasi Pontianak, especially in mathematical logic material.

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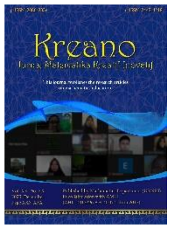
Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 361-372



TPACK Competency Analysis of Prospective Mathematics Teacher in Micro Teaching Subjects

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Abstract

In education, the integration of technology is becoming increasingly important. This is especially true for mathematics teachers, who must use technology effectively to enhance the learning experience for their students. One method for assessing a mathematics teacher's ability to integrate technology into their teaching practice is through TPACK competency analysis. The purpose of this study was to analyze the TPACK abilities possessed by a future teacher candidate through the microteaching course he has attended. This study used a qualitative method in which data were obtained from interviews and questionnaires distributed via WhatsApp. The results of this study showed that prospective teachers who were the subjects of this study were capable and proficient enough in using and utilizing technology in learning but were still unable to match learning methods and models with the material to be taught to students in the learning tools they compiled. Through this research, it is hoped that students who are prospective teachers of mathematics will deepen their mastery of learning methods and models which will be applied when they teach. The implications of these findings highlight the importance of increased training in developing the TPACK competency of prospective mathematics teachers.

Keywords: TPACK ability; Prospective Mathematics Teachers; Microteaching.

Information of Article

Subject classification	*97B50 Mathematics teacher education*
Submitted	*29 March 2023*
Review Start	*31 March 2023*
Initial Review Finish	*31 March 2023*
Round 1 Finish	*14 April 2023*
Round 2 Finish	*16 June 2023*
Accepted	*31 October 2023*
Published	*1 Desember 2023*
Similarity Check	*15%*

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Abstrak

Di bidang pendidikan, integrasi teknologi menjadi semakin penting. Hal ini terutama berlaku untuk guru matematika, yang harus memanfaatkan teknologi secara efektif untuk meningkatkan pengalaman belajar bagi siswanya. Salah satu metode untuk menilai kemampuan guru matematika dalam mengintegrasikan teknologi ke dalam praktik mengajarnya adalah melalui analisis kompetensi TPACK. Tujuan dari penelitian ini untuk menganalisis kemampuan TPACK yang dimiliki oleh seorang calon guru masa depan melalui mata kuliah microteaching yang telah diikutinya. Penelitian ini menggunakan metode kualitatif yang mana data diperoleh dari hasil wawancara dan pengisian kuisioner yang sebar melalui WhatsApp. Hasil penelitian ini diperoleh bahwa calon guru yang menjadi subjek penelitian ini telah mampu dan cukup mahir dalam penggunaan dan pemanfaatan teknologi dalam pembelajaran, namun masih belum mampu dalam mencocokkan metode dan model pembelajaran dengan materi yang akan diajarkan kepada siswa dalam perangkat pembelajaran yang mereka susun. Melalui penelitian ini diharapkan mahasiswa calon guru matematika dapat memperdalam penguasaannya terhadap metode dan model pembelajaran yang akan diterapkan pada saat mereka mengajar. Implikasi dari temuan ini menyoroti pentingnya peningkatan pelatihan dalam pengembangan kompetensi TPACK calon guru matematika.

INTRODUCTION

Education according to Putri D.S and Suyitno (Sartika, N.S., 2021) is something that is universal activity in human life, which is essentially a process in developing everyone for life and their survival and conscious efforts to shape them into independent adults. that make changes for the better in knowledge, behavior, and attitudes. Teachers are a very important part of organizing education to achieve the expected learning objectives and can create conducive learning conditions (Yurinda & Widyasari, 2022). The teacher is an important component in the learning process. In Law No. 14 of 2005 concerning Teachers and Lecturers (Turmudzi & Kurniawan, 2021) teachers are defined as professional educators whose main task is to educate, teach, train, and evaluate early childhood through formal education, basic education, and secondary education. Therefore, teachers are required to have certain competencies to carry out the learning process properly. Teacher professionalism is closely related to teacher welfare and the level of teacher education, both formal and non-formal. The professionalism of a teacher can look from two aspects, namely from the level of education he has taken and from the aspects of teacher mastery of the material, class mastery, and managing the learning process (Hafinda, 2022).

According to Ashifa S (2022), a professional teacher must also have several competencies within himself. Teachers can be categorized as professional teachers if they have pedagogic competence, personal competence, social competence, and professional competence as stated in Law Number 14 of 2005 concerning Teachers and Lecturers Article 10 paragraph (1).

According to Ismail et al., (2020) In addition, candidate of mathematics teachers should master educational competencies, technology commercialization competencies, globalization competencies, future strategy competencies, and counselor competencies, in addition to mastering the four core competencies of the law. With the rapid development of technology, teachers are expected to be able to integrate technology into teaching well. Efforts can be made by the teacher of them by using learning media such as visual aids in the learning process. This is done so that students can absorb and understand exactly what is conveyed by the teacher so that learning objectives can be achieved as they should (Murtiyasa & Atikah, 2021).

According to Nurdiana (2016) integrating technology, pedagogical, and content in the learning process can create a new framework for teachers to be able to create a learning process called TPACK.

TPACK is a framework that can collaborate between aspects of technological knowledge and content so that TPACK raises a new paradigm, of how to teach or provide stimulus in learning.

The Faculty of Teacher Training and Education at UNMA-Banten prepares mathematics students to become competent teachers in their field, with mastery of pedagogics and mastery of technology that is increasingly developing in the world of education. With a better technological pedagogical content knowledge (TPACK) concept, it is hoped that prospective mathematics teachers will be able to develop their abilities well too. The relationship between TPACK components is described as follows:

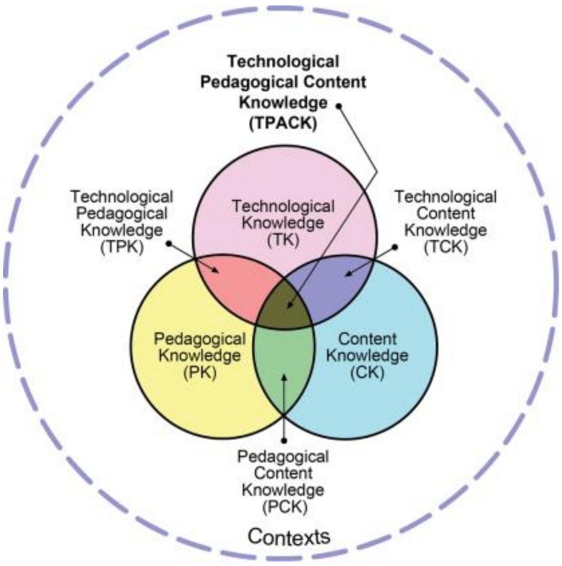

Figure 1. The TPACK framework according to Koehler et al., (Zulhazlinda W. et al., 2023).

Annisa F, et al., (2023) says that the function of microteaching learning is divided into several types, the first is a function instructional which explains that microteaching is useful for developing competence and teaching skills. Then there is a coaching function that is useful for debriefing prospective educators before carrying out the actual teaching process. Next is integralistic function because microteaching is included in the Field Experience Program and the last is the experimental function, namely this course is used as experimental material for prospective educators. So, it can be concluded that microteaching is indeed very important for students who will become teachers in the future.

According to Herawati (2021), teacher competency standards are a parameter that must be owned by a teacher both knowledge, skills, and values as a reference for improving teacher quality in improving the learning process. knowledge insight needs to be mastered by teachers as the main capital in teaching in the classroom is called Content Knowledge or content knowledge. Science and technology progress supports the delivery of learning materials. Teachers can utilize technology in classroom learning ranging from simple technology to modern technology. Another factor that is an important part of learning is the teacher's ability to convey learning material in the class called the ability of Pedagogical Content Knowledge (PCK), Putranti (2020).

Amrizal stated that a professional teacher is a teacher who can adapt and develop himself with the development of increasingly sophisticated science and technology. Competent teachers must also be able to apply learning models and methods based on time demands and the needs of students (Herawati, 2021). The TPACK capability of professional teachers in Indonesia is still faced with various problems, this must be the center of serious attention from related parties. Especially professional teachers so that they do not hinder the implementation of education in the use of TPACK in learning Mathematics (Yurinda, B & Widyasari, N, 2022).

Satriawati et al., (2022) revealed

that to achieve the competence of prospective mathematics teachers in micro-teaching courses, students must understand mathematical material (content), the ability to convey or teach (pedagogy) mathematics material properly and correctly, and the ability to create or compile indicators learning or achievement indicators based on basic competencies in the 2013 curriculum. A prospective mathematics teacher must have a deep understanding of the subject matter he will teach. They must be able to accurately explain mathematical concepts and provide real-world examples to aid student understanding. Without a strong content knowledge base, it is difficult for a teacher to integrate technology effectively into their lessons.

Implications for Future Classrooms The development of TPACK competencies through the micro teaching subject has significant implications for future classrooms of future mathematics teachers. By integrating technology, pedagogy, and content knowledge, these teachers are better equipped to create engaging learning environments that promote deep understanding of mathematics and facilitate student-centered learning experiences. In their future classrooms, aspiring mathematics teachers with strong TPACK competencies can leverage technology to differentiate instruction and personalize the learning experience. They can leverage online resources, educational software, and virtual manipulatives to provide additional support for struggling students and challenging advanced students. Additionally, they can encourage collaborative problem solving, facilitate discussion, and provide timely feedback using digital platforms. So that it is hoped that the prospective mathematics teachers who will be produced will not only be professional teachers who master pedagogic competencies, personality competencies, social competencies, and professional competencies but also be able to master technology and utilize it in learning.

METHOD

The type of research used is descriptive with a quantitative approach, while the research method uses a survey with mathematics university student Mathla'ul Anwar as the subject of this research. The research was carried out in the even semester of the 2021/2022 on Mei-June 2022, with 4 (four) students in the mathematics education study program as subjects. This study aims to analyze and describe the TPACK Competence of Prospective Mathematics Students in Micro Teaching Subjects. The research object is seven aspects of TPACK's abilities including technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). Researchers as the main instrument in this study and supporting instruments are in the form of questionnaires and interviews. Each statement on the questionnaire has the following answer options: Strongly Agree (SS), Agree (S), Disagree (TS), and Strongly Disagree (STS). With a weighted score, if the research subject answers Strongly Agree, you get a score of 4, if you answer Agree, you get a score of 3, if you answer Disagree, you get a score of 2, and if you answer strongly disagree, you get a score of 1.

The stages in this study were that mathematics students who had attended the microteaching class were given a questionnaire regarding their knowledge of TPACK and what things they had learned while attending the microteaching class. After the subject filled out the questionnaire, the subject was then given interview questions about matters related to the microteaching course and regarding the knowledge and importance of TPCK abilities for prospective teachers. In this study, the subjects studied were mathematics students at Mathla'ul Anwar University-Banten semester seven who had taken microteaching courses so that they could answer each of the questions available in the questionnaire that had been distributed via the Google form.

The research data obtained will be analyzed with descriptive statistics and document analysis. The data analysis procedure was produced from research instruments that used a Likert scale according to table 1. The Likert scale is a scale used to measure the perceptions, attitudes, or opinions of a person or group regarding an event or social phenomenon (Pranatawijaya, V. H et al., 2019).

Table 1. Category Likert Scale

Interval s	Information
3,25 < Score ≤ 4,00	Very Good
2,50 < Score ≤ 3,25	Good
1,75 < Score ≤ 2,50	Not Enough
1,00 < Score ≤ 1,75	Very Less

The formula used to convert the scores obtained into percentages is as follows:

$$Value = \frac{obtained\ score}{maximum\ score}\ X\ 100\%$$

The data obtained is then changed in the criteria in table 2.

Table 2. Percentage Range and Qualitative Criteria

Score	Range	Qualitative Criteria
1	0-20	Very Poor
2	21-40	Less
3	41-60	Enough
4	61-80	Good
5	81-100	Very Good

RESULTS AND DICUSSION

Results

Koehler M. J, et al., (Herizal et al., 2022) stated that the TPACK model consists of three main components and four combined components. The main components are technological knowledge (Technological Knowledge-TK), pedagogic knowledge (Pedagogical Knowledge-PK), and content knowledge (Content Knowledge-CK). The four components which are a combination/integration of these main components are Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (TPACK).

TPCK is a dynamic framework for describing knowledge that teachers can rely on in designing and implementing curriculum and learning, as well as guiding students to think and learn using technology. Technology can be custom-made to address the pedagogical need to teach appropriate content in each context. Nur Atikah (Yohana R, 2020) added that the TPCK framework describes the various types of knowledge that teachers and prospective teachers need to teach effectively with the help of technology and various complex procedures in the field of knowledge interaction.

The results of the assessment were obtained from questionnaire answers and interviews conducted with students who were the subjects of this study. Of the seven TPACK components with each indicator accompanying them, they were compiled into questionnaire items which were distributed to students who had taken the microteaching course to find out how far they had studied classroom management in mega-teaching learning activities, developing learning strategies, making learning media, and understand the material that will be taught to students in class. The questionnaire and interview sheet were distributed using the Google form via WhatsApp, then the results of the questionnaire and interview sheet were analyzed to get the results of this study.

From the results of the questionnaire, it was found that the research subjects (mathematics students) in this study were able and strongly agreed with the use of technology in the teaching and learning process in the classroom. Especially in 21st-century learning, learning already uses a HOTS level of thinking which really needs and dependence on technology is growing rapidly. Learning is not only centered on the teacher but uses learning media that utilize current technological sophistication, for example through the media of powerpoint presentations, learning videos, and so on which cannot be separated from the use of technology. Therefore, teachers in this era must be able to use computer/laptop technology properly, especially smartphones.

In the following, tables and graphs are presented from the results of the questionnaire that was distributed to the seventh-semester students who were the subject of this study. The research subjects used were students taking micro-teaching courses.

Table 3. TPACK Aspect Average Value

Subject code	TPACK Score (%)	Criteria
S1	2,95	Good
S2	3,35	Very Good
S3	3	Good
S4	3,25	Good

From the results of the questionnaire, it was found that the subjects in the study were obtained if the prospective teacher mathematics students were good at understanding and using technology as a support for teaching and learning activities in class. Subject 1 (S1) has an average score of 2.95 with good criteria so he is considered capable of preparing himself to be a future teacher candidate. Likewise, the other three subjects had scores above subject 1 (S1) with good criteria. Especially S2 who got a score of 3.35 with very good criteria.

The following results from the average value of the TPACK aspect are presented in the form of a pie chart.

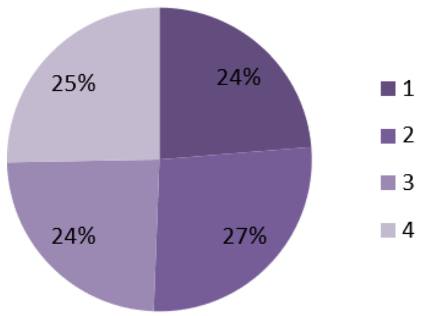

Figure 2. Percentage of the average value of the TACK aspect

According to Sahidin (Sahidin, et al., 2022), the technology referred to here is the technology that can assist teachers in representing concepts, principles, and procedures. To carry out online learning, students need to search the internet (library sites and databases) and use e-mail or short messages to communicate with peers for learning activities. On the other hand, Rahayu, et al added that teachers need competence which includes content knowledge, pedagogic knowledge, and Technological Pedagogical and Content Knowledge (TPACK) in accommodating online learning activities. Mishra & Koehler (Sahidin L et al., 2022) said TPACK is a framework that introduces the relationship and complexity between the three basic components of knowledge (technology, pedagogy, and content).

Students who are the subject of this study are all capable of using and operating both laptops and computers well, especially smartphones which are addictive in their daily activities. The research subjects were able to operate Microsoft Word, PowerPoint, and Excel applications well, by using these applications they could make learning tools including making interesting learning media through attractive PowerPoint presentations for the students they teach in class.

Based on the results of this study, the subject is considered capable of using technology in the teaching and learning process in the classroom. Such things are also taught in microteaching courses. Microteaching is a compulsory subject that must be taken by all prospective teachers. According to Fatwanto et al., (Novianti & Khaulah S, 2022) Microteaching is a course that is theoretical and applicable to all the learning experiences that have been experienced by students so far to become a preparatory training program in mastering various teacher competencies so that they can be responsible and Trust professionally. In practice, students or prospective teachers act as teachers practicing giving material to their students, whereas those who act as students are their classmates who are formed in small groups so that their application is also limited by a predetermined time and is monitored and assessed by the supervising lecturer. Those courses. With the microteaching course, prospective teacher students can learn how to prepare themselves as prospective teachers to go directly to school properly. Learn how to be a good teacher, prepare learning methods and models, learn class control, and so on that are needed in the process of teaching and learning activities in class.

The teaching and learning process in the classroom is supported by various learning tools and teaching aids to assist teaching and learning activities so that the learning process takes place effectively and conductively. The learning device used as a reference in learning activities is the RPP (Learning Implementation Plan) whose contents include school identity, learning time allocation, learning steps, as well as learning methods and materials that will be given to students.

In the Ministry of Education and Culture (2016) based on the 2013 curriculum process standards, lesson plans must contain school identity, subjects, class/semester, subject matter, time allocation, learning objectives, learning competencies, learning materials, learning methods/models, learning media, learning resources, learning steps, and assessment (Hasanah, R.u & Siregar, T.J, 2022).

In microteaching courses, students are taught and guided in making learning tools such as lesson plans, syllabus, semester program, and annual program, determining effective weeks in the educational calendar, and adjusting learning methods and models according to the material to be taught to students. Paying attention to TPACK which is mastered by prospective mathematics teachers will make it easier to develop effective and efficient learning tools during the learning process in class. The emergence of technology in learning mathematics is one of the strategies that can be used to make abstract mathematical concepts more concrete. Aija and Inga (2012) describe the various benefits of technology in the learning process, namely increasing student learning motivation because the mathematical content presented is by developments in the digital era, helping students associate concepts with students' initial abilities, helping teachers create different learning atmosphere, the learning process is more visual, concrete, fun, and interesting.

Sumarni et al., (2019) argued that

teaching knowledge in the field of mathematics education usually called mathematics content knowledge (MKT), is an important thing that prospective teachers must have. Teachers need to teach math material by the applicable curriculum and carry out creative learning to build students' thinking skills. Especially in improving higher-order thinking skills (HOTS), and associating abstract material with concrete things in everyday life. To be able to do this, prospective teachers must be able to determine learning methods and models that are appropriate to the material to be taught so that students easily understand and grasp the meaning of what the teacher teaches so that the learning objectives desired by the teacher can be achieved properly.

The pedagogical competence of prospective mathematics teachers is influenced by their self-confidence in the form of teaching skills and conveying mathematical concepts to improve student achievement (Nugroho W, 2022). Isnaniah and Imamuddin M (2022) argue that prospective mathematics teachers are students of mathematics education who are practicing having basic teaching skills in order to convey mathematics material to students. Mathematical material is material that is full of concepts, facts, principles, and procedures. Imamuddin added that the relationship between mathematical concepts is very tight so in studying mathematics, students must start from simple concepts and then move on to complex mathematical concepts. Mathematics is one of the subjects that studies abstract material so it requires teachers to have good skills in relating material to everyday life so that abstract material can be digested and understood well by their students. For this reason, the ability of Content Knowledge (CK) must be owned by a teacher.

Discussion

The world of education is required to always adapt to the times, especially in terms of technology. Prospective teachers as an important element in education are expected to be able to have three knowledge namely pedagogy, content, technology, and a combination of the three which is commonly called Technological Pedagogical and Content Knowledge (TPACK) so that they are ready to become professional teachers in the 21st century. In the following, some research results from previous researchers are presented regarding the TPACK ability of prospective mathematics teachers both in microteaching courses and so on. Based on the results of the research (Hafinda T, 2022) the data findings and analysis results obtained outline the teaching abilities of prospective Madrasah Ibtidaiyah teacher candidates for the Madrasah Ibtidaiyah Teacher Education Study Program STAIN Teungku Dirundeng Meulaoh in terms of Technological Pedagogical and Content Knowledge (TPACK) in the Learning subject MI/SD Mathematics is in a low category. It can be seen from the six aspects of the review that the average is in a low category.

Based on research (Novianti and Khaulah S, 2022), the research results obtained were that the microteaching learning activities carried out by students of the Mathematics Education Study Program, Faculty of Teaching and Education, Almuslim University were very good, but there were two criteria that there were still frequent exercises. and must be more focused, including on the criteria for speaking skills and closing activities. From these two criteria, it is expected that students can learn from experience can improve their speaking skills and improve their ability to close lessons.

Based on the research results of Turmuzi M and Kurniawan E (2021), it was found that the ability to teach prospective mathematics teachers in terms of Technological Pedagogical and Content Knowledge (TPACK) in the Micro Teaching course is described as follows: has an average standard deviation of 0.75, average -an average percentage of 77.80% and an average mean of 3.89 in the medium category.

The results of Muhtadi D. et al., (2022) show that a technology-based learning approach can play an effective role in preparing and improving TPACK competencies for mathematics teachers. Research according to Murtiyasa B and Atikah M.D (2021), shows that the TPACK abilities of prospective mathematics teacher students in the Practicum course for Making Mathematics Teaching Aids are in a good category. Each aspect of TPACK is also in the good category. Prospective math teacher students already understand aspects of TPACK abilities well and must still be honed and developed so that their current understanding does not stop here because technology will continue to develop over time.

From the research results of previous researchers, it can be concluded that TPACK abilities are very necessary for prospective teachers, especially math teachers, in carrying out their duties. Having good mastery of technology will make learning easier and more interesting for students, because in the 21st century, learning is technology-based. For teachers who are unable to use increasingly developing technology, it will be difficult for teachers to catch up with increasingly advanced and sophisticated technological developments. Everything can be accessed through certain websites, even the internet has become an inseparable need in educational life at this time.

From the results of this study, it was found that these prospective mathematics teacher students who were the subjects of this study had been well prepared by the faculty of Mathematics Education FKIP to welcome them into becoming qualified future teachers, although there were still many shortcomings and inadequacies for some students in several ways, for example in compiling good learning tools by the applicable provisions in a predetermined curriculum.

21st-century learning prioritizes the ability of teachers to access and manage learning by utilizing technology and the internet which are increasingly well-developed. Because learning in the 21st era has applied HOT learning or high-level critical thinking, teachers in this century must be even smarter. The material is easily accessible through websites or other sources using free and wide internet access. So that not only teachers can access it but students can easily access it.

The teacher's ability in classroom management must be more advanced because if the teacher still uses conventional methods or lecture methods then learning will remain stagnant or not develop. In fact, it will be very far from being advanced if there are no changes in learning methods and models. In practice, it will indeed be a little difficult to apply creative, innovative learning using increasingly advanced technology, but that doesn't mean it can't be applied. Young teachers and prospective teachers must be able to become creative teachers in class management during the process of teaching and learning activities in class.

From the results of this study, it was found that the students who were the sample in this study had prepared themselves as well as possible to become creative, innovative, and sporty young teachers in carrying out their duties as facilitators to educate this nation's generation. Students have learned a lot about learning tools, changing or matching methods with the material to be taught to students, and preparing by studying and following technological developments that are increasingly advancing rapidly.

Technological Pedagogical and Content Knowledge (TPACK) skills must be possessed by all future teacher candidates so that education in Indonesia is more advanced and not out of date. Moreover, learning in the 21st-century era emphasizes technology with high-order thinking skills which must be balanced with qualified teachers to produce quality products (students) as well. The following describes some of the results of interviews with prospective teacher students in responding and preparing themselves to become good teachers while attending the microteaching course, with the description P being Researcher and S1 being Subject one, and so on.

Q : What do you need to prepare in your process of becoming a teacher?
S1 : Mental, knowledge, experience, and good intentions
S2 : Of course, good education, broad insight, teaching skills, good attitude to be role models for students as well as personal competence, pedagogic competence, social competence, and professional competence.
S3 : Teaching modules and media for learning
S4 : Studying/finalizing the material that we will teach to students.

Q : Do you think a teacher is obligated to use technology that is increasingly developing in the teaching and learning process? Why?
S1 : Yes, it is mandatory. Because technology is very important for teachers.
S2 : Mandatory. Because teachers must be literate about technology.
S3 : Mandatory, to adapt learning in today's world.
S4 : Mandatory. Because education is increasingly advanced with rapidly developing technology.

Q : Are microteaching courses required in the lecture process? Why?
S1 : Very necessary, as a training ground for how we teach and get involved in the real world of education.
S2 : Very necessary. Because micro-teaching learning aims to foster prospective teachers to have knowledge and skills about the learning process. In addition, another goal to be obtained from micro-teaching learning is to grow the self-confidence of prospective teachers so that they can teach and manage real classes.
S3 : It is necessary to train students in conveying a lesson.
S4 : Very necessary. Because prospective teachers can practice first in college.

Q : What did you learn while teaching micro-teaching courses?
S1 : Method, pedagogic competence, and so on.
S2 : Preparing good learning tools, skills in teaching, how to manage classes well, and so on.
S3 : Make Rpp, porta promissory note, and train to get used to appearing in front of many people.
S4 : Method of delivery, assessment, materials, and so on.

Q : What impact did you feel after teaching the microteaching course?
S1 : It has had a big impact on me personally, especially since I don't have much experience teaching at the high school level.
S2 : Lots of them, with the microteaching course, I know how to manage classes well, how to deliver interesting lessons and the teaching skills that prospective educators must master.
S3 : More confident.
S4 : There are pictures of when you are going to teach at school.

Based on the results of these interviews which has been carried out on june 20 2022, for prospective 21st-century teachers, the ability to operate technology is indeed very important. The TPACK ability possessed by a teacher will determine the quality of learning that occurs in class, the better the quality of the TPACK ability possessed by the teacher, the better the learning will be carried out and will produce good-quality students.

Implication

In conducting this research, the researcher tried to do everything best to obtain satisfactory results. This study aims to analyze the ability of TPACK student teacher candidates in attending micro-teaching lectures, and whether they can carry out their duties as good future teachers in preparing a highly competitive nation's generation. The research findings show that the TPACK Competency Analysis (Technological Pedagogical Content Knowledge) of prospective mathematics teachers in micro-subjects is very important for their development and effectiveness in the classroom. This means that teacher education programs need to prioritize the integration of technology, pedagogy, and content knowledge in their curricula to enhance the TPACK competencies of future mathematics teachers.

Limitation

One of the limitations of the TPACK competency analysis research for prospective mathematics teachers in the micro teaching subject is the potential for bias in the assessment of their competence. Ratings can be influenced by the subjective opinion of the rater, leading to potential inconsistencies and inaccuracies in the analysis. In addition, the sample size of prospective mathematics teachers involved in this study may be relatively small, which may limit the generalizability of the findings to the wider population. In addition, the duration of the micro-teaching sessions may not be sufficient to fully assess and capture the complexities of the prospective mathematics teacher's TPACK competencies.

CONCLUSSION

From the results of this study, it was found that the subjects in this study were able to use and apply technology well as a source of learning in learning. From the results of the study, it was found that the TPACK capabilities of prospective teacher students were quite good because all of them were able to operate Microsoft well, they could use it in learning, both as a learning resource or as a learning support application.

Included a tool to create learning tools that support teaching and learning activities in the classroom. Nevertheless, there are still some difficulties for prospective teacher students in making lesson plans, especially in determining the method or model that is appropriate to the material to be used during learning. For this reason, it is necessary to increase the material for preparing learning tools so that they are even better at preparing good learning tools. In preparing learning tools, it must be further deepened so that there are no mistakes in determining between the material and the learning method or model used.

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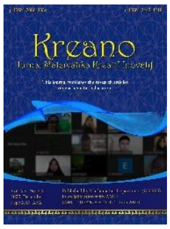
Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 373-385



Development of Four-tier Multiple-choices Test to Diagnose Student's Misconception

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Abstract

Studies in Indonesia delineate that junior high school students in Indonesia have low mastery of circle material. Students with low mastery of the material tend to have misconceptions. The goal of this study is to develop a four-tier diagnostic test for circle material to identify the level of their understanding, including misconception in circle material. This development used the ADDIE model. It comprises four phases: Analysis, Design, Development, Implementation, and Evaluation. The test developed consists of 20 items which four experts in learning mathematics have validated. They are two lecturers and two teachers of mathematics who have teaching experience of more than ten years. The validated test was implemented on 34 grade 8 students in Yogyakarta. From the test results obtained information, of the 20 test items, on average, have an ideal difficulty level. All items have a good discriminant index. Test reliability was estimated using the Cronbach Alpha formula. The estimation results show a test reliability coefficient of 0.72. Students as test respondents stated that the tests developed contained easy-to-understand instructions, easy-to-understand language, sufficient test time, clear pictures, and enough items. This test can help junior high school mathematics teachers in Indonesia to identify their students' misconceptions and level of understanding, especially regarding circle material.

***Keywords**: circle,* diagnosis, *four-tier, test*

Information of Article

Subject classification	*97D60 Student assessment, achievement control, and rating*
Submitted	*22 June 2023*
Review Start	*25 June 2023*
Initial Review Finish	*21 August 2023*
Round 1 Finish	*21 October 2023*
Accepted	*23 October 2023*
Published	*1 Desember 2023*
Similarity Check	*10%*

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Abstrak

Hasil-hasil studi *menunjukkan siswa sekolah menengah pertama di Indonesia memiliki penguasaan yang rendah pada materi lingkaran. Siswa dengan penguasaan materi yang rendah terindikasi mengalami miskonsepsi. Penelitian ini bertujuan untuk mengembangkan tes diagnostik tipe four-tier pada materi lingkaran untuk mendiagnosis level pemahaman siswa pada materi lingkaran, termasuk miskonsepsi yang dialami siswa. Pengembangan ini menggunakan model ADDIE (Analysis, Design, Devalopment, Implementation, Evaluation). Tes yang dikembangkan terdiri atas 20 butir yang telah divalidasi oleh 4 orang ahli dalam pembelajaran matematika yang terdiri atas 2 orang dosen pembelajaran matematika dan 2 orang guru matematika yang memiliki pengalaman mengajar lebih dari 10 tahun. Tes yang sudah divalidasi diujicobakan kepada 34 siswa kelas 8 di Yogyakarta. Dari hasil uji coba didapat informasi bahwa dari 20 butir soal tes rata-rata memiliki tingkat kesukaran yang ideal. Keseluruhan butir memiliki daya pembeda yang baik. Keandalan tes diestimasi dengan menggunakan formula Cronbach Alpha. Hasil estimasi menunjukkan koefisien reliabilitas tes sebesar 0,72. Siswa sebagai responden uji coba menyatakan bahwa tes yang dikembangkan memuat petunjuk yang mudah dimengerti, bahasa yang mudah dipahami, waktu tes yang cukup, gambar yang jelas, dan jumlah butir soal yang cukup. Tes yang dikembangkan ini dapat membantu guru matematika sekolah menengah pertama di Indonesia untuk mengidentifikasi miskonsepsi dan level pemahaman siswanya, khususnya pada materi lingkaran.*

INTRODUCTION

Recently, STEM was being integrated into teaching. "STEM" refers to a multidisciplinary educational perspective combining mathematics with science, technology, and engineering (Chesky & Wolfmeyer, 2015). Mathematics has a more vital role in those fields because it supports students in mastering other fields (Shim, Shakawi, & Azizan, 2017). There are a lot of occupations, notably in science, technology, and engineering, that depends on mathematics (Li & Schoenfeld, 2019), even daily activities. In science, for example, mathematics supports the development of formulas to find unknown geometric and parameter values related to inheritance, measurements, and relationships of points, numbers, angles, and lines in space (Swaranjit, 2015).

The important role of mathematics makes it necessary for Indonesian students to learn mathematics from elementary education to higher education. To evaluate students' performance in mathematics, several types of assessments are conducted in Indonesia education system, such as assessments by teachers, schools, and the government. The type of assessment used to evaluate is formative and summative. Summative evaluations are used to assess students' learning, skill development, and academic achievement, whereas formative assessments are utilized by teachers to modify their teaching and learning practices and increase student progress (Bhat, 2019).

The national examination was the formative assessment conducted by Indonesia government. The subjects tested, especially at the junior high school (JHS) level, consist of mathematics, Indonesian, English, and sciences. The results of the national exam on several occasions showed that the average mathematics score of students taking national exams in Indonesia was the lowest among other subjects tested in the national examination (Prabowo, Rahmawati, & Anggoro, 2019). Only 46.19 out of a possible 100 points were earned on average by Indonesian students in mathematics in the last period. Mastery of Indonesian, English, and Sciences material was 66.12, 50.96, and 49.43, respectively. It indicates that mathematics is the most difficult for JHS students in Indonesia. Studies also reveal that mathematics is complicated (Setiana, Ili, Rumasoreng, & Prabowo, 2020) and commonly perceived to be difficult (Fritz, Haase, & Rasanen, 2019).

The content of mathematics in Indonesia JHS students contains numbers, algebra, geometry and measurement, statistics, and probability. In more detail, of the various mathematics materials tested, geometry and measurement materials are classified as materials with a small average percentage of being answered correctly by students taking the national examination (Prabowo, Anggoro, Adiyanto, & Rahmawati, 2018; Retnawati, Arlinwibowo, & Sulistyaningsih, 2017).

One of the subjects tested on geometry and measurement is circle. At the last national exam, the average score of students' mastery of circle material was only 35.77. The low mastery of students in Indonesia on circle material also occurred in previous years. Indonesian students' mastery of circle material ranged from 40 to 50. The low student mastery of circle material is also described in various study results (Rejeki & Putri, 2018). The low mastery of the circle concept is related to determining the circle elements such as the center point and radius (Sudihartinih & Purniati, 2019), determining the length of the circular (Lestari, Mardiyana, & Slamet, 2020).

Low mastery of the material is closely related to misconceptions about students' comprehension of the material related (Kusmaryono, Basir, & Saputro, 2020). Misconceptions are misunderstandings and misinterpretations based on wrong meanings (Ojose, 2015). It harms students' cognitive development because they build their own concepts (Aydin, Keles, & Hasiloglu, 2012), which are far from the correct concept.

Misconceptions detected early will be easy to be corrected. To identify the students' misconceptions, the following tools might be used: interviews, open-ended questions, and multiple-choice with two or three tiers (Ojose, 2015). Using interview, students can set their own schedules and can learn more in-depth information. However, this technique needed a lot of time, and there were few respondents. For open-ended tests, which provide respondents the chance to create answers based on their own word choices, it is possible to test with a greater number of participants than in interviews. But the open-ended test has a drawback in that it takes a long time to evaluate the data and concluded. It enables ease of administration and analysis for multiple-choice examinations and can be given to many respondents. Multiple-choice exams, however, cannot distinguish between students' accurate and incorrect responses, making it impossible to undertake in-depth study on them (Kaltakci-Gurel, D., Eryilmaz & McDermott, 2017).

Development of a diagnostic test that not only has a simple administration method but can also be used with a greater number of test takers and provides detailed information on students' level of knowledge is required to address the shortcomings of previous approaches. Two-tier and three-tier multiple choice are two of the test formats that are feasible (Ojose, 2015). However, it still has limitations, one of which is that it cannot identify the reason why students actually encounter misunderstandings (Gurel, Eryilmaz, & McDermott, 2015).

The four-tier model is the diagnostic test model that can provide the most complete information in making a diagnosis. In this model, an item is equipped with answer choices, reasons for choosing answers, and the degree of confidence for each response and the reason (Caleon & Subramaniam, 2010a). This test model was originally developed on physics materials, such as optics (Caleon & Subramaniam, 2010b), optical tools, and waves (Zaleha, Samsudin, & Nugraha, 2017). This model has not been developed in the field of mathematics yet. The models developed in the field of mathematics are only two-tier (Lin, Yang, & Li, 2016). This model has a lack because it only provides alternative answers and underlying reasons for answering questions, regardless of the level of confidence students choose answers (Kutluay, 2005). Hence, it is essential to develop a four-tier diagnostic test to identify students' misconceptions about circles material.

METHOD

The diagnostic test is a kind of assessment that is part of instruction. Therefore, the ADDIE model was used in developing the diagnostic test in this study. It is one of the most widely used models for instructional design, which serves as a manual for creating successful designs, systematic, and easy to apply so that the resulting product is well-tested (Aldoobie, 2015). The steps of the ADDIE model are Analysis, Design, Development, Implementation, and Evaluation (Lu & Sides, 2022). The tasks and output of each step are presented in Table 1.

Table 1. Student Response Criteria

Steps	Tasks	Output
Analysis	Needs assessment	Problem Statement
Design	Write objectives	Measurable objective
	Create test blueprint	Test blueprint
Development	Develop diagnostic items test	Four-tier diagnostic item test
Implementation	Try out	Items characteristic
Evaluation	Revise the product	Revised the product

In the analysis phase, a need assessment was conducted to identify the problem that occurred. The problem is needing a four-tier diagnostic test to identify students' misconceptions in circles. In the design phase, objectives were determined. In this phase, the blueprint for the test was set (*see Table 2*).

Table 2. Test Blueprint

Competency	Indicator	Number of item
Explain and solve problems related to central angles, inscribed angles, arc lengths, and the sector of a circle, and their relationships	Identify the elements of a circle	1, 2, 3, 4
	Determine the circumference and area of a circle	7, 12
	Determine the relationship between the central angle and the inscribed angle	5, 6, 13
	Determine the relationship between arc length and the area of sector	8, 9, 10, 11, 14, 15

In the development phase, diagnostic items were developed based on the blueprint. At this stage, the test was validated by four experts. They are two mathematics lecturers and two mathematics teachers with more than ten years of teaching experience. In the implementation phase, the developed diagnostic item test was implemented with 34 junior high school students in Yogyakarta, Indonesia. In the evaluation phase, evaluation was carried out in all the stages (analysis, design, development, and implementation). In this phase, the test was revised based on implementation, including the characteristics of the difficulty index (Dif-I), discriminating index (Dis-I), and reliability.

Instruments and Data Collection

The instruments used in this study were the validation sheet and student response questionnaire. The type of validity analysis for the test was content validity. It represents the evidence of the degree to which the assessment components of the instrument are pertinent and represent a specific construct for a given assessment purpose, known as content validity. In contrast to other types of validity, this validity relates to test-based validity rather than score-based validity (Almanasreh, Moles, & Chen, 2019). It is determined by using expert agreement (Retnawati, 2016). The validated aspects include material, construction, language, and appearance. Aspects of student responses that were asked in the questionnaire included: instructions for clarity, material studied and tested, ease of language selection, time effectiveness, picture clarity, and the adequacy of the number of items.

Analysing of Data

To establish the test's validity, content validity analysis of expert judgment data was performed. The test is declared valid if it meets the criteria: in accordance with the indicators to be measured, the items are formulated clearly, use clear and informative language, and contain clear instructions. The validity was analyzed by using Aiken's V index formula. The following is the formulation of Aiken's item validity index.

$$V = \frac{\sum s}{n(c-1)}$$

V represents the validity index of the item. s means the scores the rater gave minus the lowest score in the category used.

$$s = r - l_o$$

r is the score given by the rater and l_o is the lowest score in the category used.

Item Difficulty Index (Dif-I) is the proportion of test takers who answered an item correctly (Sayyah et al., 2012). The following is the formulation to identify Dif-I.

$$P_i = \frac{n_i}{N}$$

P_i is the difficulty Index of item-i. n_i is the number of students who answer the item-i correctly. N is the total of students who answer the item-i. Items with Dif-I <0.3 are classified as too difficult, Dif-I > 0.7 are classified as too easy, and if Dif-I ranges from 0.3 to 0.7, it is recommended (Musa, Shaheen, & Elmardi, 2018).

Item discriminating index (Dis-I) is the difference between the percentage of examinees with high ability and those with low ability who get the items correctly. Dis-I describes how well the items differentiate student abilities (Dhakne-Palwe, Gujarathi, & Almale, 2015). Before identifying the Dis-I, students were divided to two groups (high and low group) based on their total score. The following is the formulation to identify Dis-I.

$$D_i = \frac{nU_i}{NU_i} - \frac{nL_i}{NL_i}$$

D_i is the discriminating index of item-i. nU_i is the number of students in the high group who answer the item-i correctly. NU_i is the total of students in the high group. nL_i is the number of students in the low group who answer the item-i correctly. NL_i is the total of students in the low group. The acceptable Dis-I is between 0.2 to 0.29, while more than 0.29 is good and excellent (Shete, Kausar, Lakhkar, & Khan, 2015).

The reliability of the diagnostic test was estimated using Cronbach's Alpha Formula.

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum s^2(X_i)}{s^2(Y)}\right)$$

α is the coefficient of reliability. n refers to the number of items. $s^2(X_i)$ is the variance of item- i and $s^2(Y)$ is the variance of total scores. The test is said to be reliable if it has a reliability coefficient of more than 0.5 (Gugiu & Gugiu, 2018).

This study also identifies the student's responses to the test. A questionnaire with 8 items/statements was used to explore the quality of instructions provided, language used, time allotted, pictures presented, and number of items provided. Each item contains four alternative responses: very good (4), good (3), poor (2), and very poor (1) were used. The average of students' responses ($\bar{x}$) is categorized based on the following criteria (Table 3).

Table 3. Student Response Criteria

Interval	Criteria
$M_i + 1.8\,SB_i < \bar{x}$	Very good
$M_i + 1.8\,SB_i \geq \bar{x} > M_i + 0.6SB_i$	Good
$M_i + 0.6\,SB_i \geq \bar{x} > M_i - 0.6\,SB_i$	Moderate
$M_i - 0.6\,SB_i \geq \bar{x} > M_i - 1,.\,SB_i$	Poor
$M_i - 1.8\,SB_i > \bar{x}$	Very poor

$\bar{x}$= average score, $M_i = \frac{1}{2}$(Ideal maximum score + ideal minimum score), and $SB_i = \frac{1}{6}$(Ideal maximum score - ideal minimum score).

To identify the level of students' understanding, Table 4 presents the criteria.

Table 4. Analysis of Four-tier Diagnostic Test Items

Tier 1	Tier 2	Tier 3	Tier 4	Conclusion
F	S	F	S	Misconceptions (M)
F	S	F	NS	Does not understand the concept (NU)
F	NS	F	S	
F	NS	F	NS	
R	S	R	S	Understands the concept (UC)
R	S	R	NS	
R	NS	R	S	
R	NS	R	NS	
R	S	F	S	Partial understanding (PU)
R	S	F	NS	
R	NS	F	S	
R	NS	F	NS	
F	S	R	S	
F	S	R	NS	
F	NS	R	S	
F	NS	R	NS	

(Rawh, Samsudin, & Nugraha, 2020)
F = False; R = Right; S = Sure; NS = Not Sure

Students are categorized as having misconceptions if they are wrong and sure in answering questions and giving reasons. Students are categorized as not understanding the concept if they are wrong and sure about answering questions and wrong and not sure in giving reasons, wrong and not sure about answering questions and wrong and sure in giving reasons, and wrong and not sure about answering questions and giving reasons.

Students are categorized as understanding the concept if they are correct and confident in answering questions and giving reasons, correct and confident in answering questions and correct but not confident in giving reasons, correct but unsure in answering the question and correct and confident in giving reasons, correct but not sure in answering the question and giving reasons, correct and confident in answering questions but incorrect and confident in giving reasons, and correct and confident in answering questions but incorrect and unsure in giving reasons.

Students are categorized as having partial understanding of the concept if they are correct and confident in answering questions and giving reasons, correct and confident in answering questions and correct but not confident in giving reasons, correct but unsure in answering the question and correct and confident in giving reasons, correct but not sure in answering the question and giving reasons, correct and confident in answering questions but incorrect and confident in giving reasons, and correct and confident in answering questions but incorrect and unsure in giving reasons.

RESULTS AND DISCUSSION

Results

The Stages of Four-Tier Diagnostic Test Development

The development of a four-tier diagnostic test for 8th students in Indonesia at circle material was started with the analysis phase. In this phase, problems in instruction were identified. First, junior high school students in Indonesia had difficulties in mastering circle material. Second, this difficulty needs to be diagnosed to identify students' strengths and weaknesses in circle material. The diagnosis can also give a preview of the category of students' misconceptions in circle.

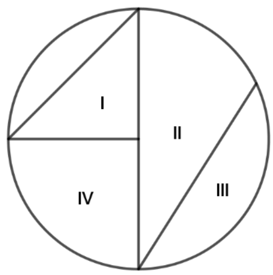
Based on the analysis, the objective of the design phase of the study was to develop a four-tier type diagnostic test instrument for circle material. The blueprint of the test was created. The content of the material referred to the curriculum in Indonesia regarding the basic competencies that students in Indonesia want to achieve, especially in the basic competency points for mathematics of 8th grade (competency numbers 3.7 and 4.7). The blueprint consists of the measured basic competency, indicators, type, and number of items.

The test was developed based on the blueprint. Four-tier items with four options are the type of test. The level of confidence is "sure" and "not sure". The test consists of 20 items. It had been validated by two experienced mathematics lecturers and two experienced mathematics teachers. Their judgment was analyzed by using Aiken's V formula. Its Aiken's V index was 0.95. The minimum index to state the valid instrument (4 raters with 4 options) is a minimum of 0.92 (Aiken, 1985). It means the test is valid.

Table 5 presents one of the sample questions. This item measures the student's ability to show the elements of a circle, in this case, the sector of the circle.

The valid test was implemented on 34 junior high school students in Yogyakarta. They did 20 items test and gave the response of the implementation of the test. It was conducted by using a paper-based test. The responses were analyzed to identify the Dif-I, Dis-I, coefficient of reliability, students' responses, and their level of concept understanding in circle.

Table 5. Four-Tier Diagnostic Test Item

Tier		Question
Tier 1	:	1. Look at the following picture!  The sector of a circle is indicated by the number.... A. I B. II C. III D. IV
Tier 2	:	My level of confidence in choosing the answer: ○ Sure ○ Not sure
Tier 3	:	The reason I chose the answer: A. because the sector is the area bounded by arc and chord B. because the sector is the area bounded by diameter and arc C. because the sector is the area bounded by an arc and two radiuses D. because the sector is the area bounded by a chord and two radiuses
Tier 4	:	My level of confidence in choosing the reason for the answer: ○ Sure ○ Not sure

The Difficulty Index Items of Four-tier Diagnostic Test

The results of the student's answers were analyzed quantitatively to determine the DIf-I, Dis-I, and reliability of the test. Table 6 presents the level of difficulty of each item and the percentage of each level.

Table 6. The Level of Difficulty of the Items

Item number	Dif-I	Criteria
1	0.45	Moderate
2	0.55	Moderate
3	0.75	Too easy
4	0.55	Moderate
5	0.45	Moderate
6	0.65	Moderate
7	0.60	Moderate
8	0.60	Moderate
9	0.65	Moderate
10	0.35	Moderate
11	0.60	Moderate
12	0.65	Moderate
13	0.75	Too easy
14	0.55	Moderate
15	0.80	Too easy
16	0.40	Moderate
17	0.75	Too easy
18	0.45	Moderate
19	0.60	Moderate
20	0.60	Moderate

Table 7. Percentage of Each Level of Difficulty

Criteria	Items Number	Quantity	Percentage
Too easy	3, 13, 15, 17	4	20%
Moderate	1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 14, 15, 16, 18, 19, 20	16	80%
Too difficult	-	0	0%

Tables 6 and 7 show that of the 20 items, there are four items (20%) that are too easy (items numbers 3, 11, 13, 17). The other items are moderate.

The Discriminant Index Items of Four-tier Diagnostic Test

The Dis-I is of each item presented in Table 8.

Table 8. The Discrimination Index of the Items

Item number	Dis-I	Criteria
1	0.3	Excellent
2	0.5	Excellent
3	0.3	Excellent
4	0.5	Excellent
5	0.3	Excellent
6	0.3	Excellent
7	0.4	Excellent
8	0.2	Acceptable
9	0.3	Excellent
10	0.3	Excellent
11	0.4	Excellent
12	0.4	Excellent
13	0.3	Excellent
14	0.3	Excellent
15	0.2	Acceptable
16	0.2	Acceptable
17	0.3	Excellent
18	0.3	Excellent
19	0.4	Excellent
20	0.4	Excellent

Table 9. Percentage of Each Criterion of the Discrimination Index

Criteria	Items Number	Quantity	%
Acceptable	8, 15, 16	3	15%
Excellent	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 17, 18, 19, 20	17	85%

Table 8 and 9 present that of the 20 items, all of them (100%) have acceptable and excellent Dis-I.

The Reliability of Four-tier Diagnostic Test

The reliability of the test is indicated by the coefficient of reliability. It was estimated by using Cronbach Alpha formula. Measured by using the SPSS package program, obtained the reliability coefficient of 0.72.

The Response of the Students toward the Four-tier Diagnostic Test

Students' responses to the tests developed are shown in table 10.

Table 10. Student Responses

Statement	Score	Category
The instructions provided are clear and easy to understand	3.44	Very good
The language used in the questions is easy to understand	3.50	Very good
The time allotted is sufficient to complete the test	2.94	Good
The pictures in the questions are clear and easy to understand	3.26	Good
The number of items is sufficient	3.09	Good

To get the test runs well, the instructions were provided. It consists of the instructions to guidance students during the test. Their responses toward the instructions are clear and easy to understand. This makes them focused on the process of test. The language used in the test is Indonesia, their daily language. The structure of the sentences was constructed based on the General Guidelines for Indonesian Spelling. It makes students familiar and easy to understand the meaning of each statement. To answer 20 items, they have 80 minutes. In means in average, they have 4 minutes for each item. Student stated that it was enough to answer 20 items with four-tiers. From 20 items of, 15 of them provide the picture as the additional information of the item. Students stated that the pictures were clear and informative in supporting the information of the item. This type of test is four-tier. Each item contains four questions. This is a consideration in determining the number of questions. For the students, 20 items are enough and ideal for them to do it in their best performance.

The Level of Student's Understanding

The level of student's understanding reported based on their answer in each item and the criteria at Table 4. Table 11 presents the samples of responses of 3 students in answer item number 1.

Table 11. Sample of Students' Responses

Student	Tier 1	Tier 2	Tier 3	Tier 4	Conclusion
1	R	S	R	S	Understands the concept
2	F	S	F	S	Misconceptions
3	R	NS	F	NS	Partial understanding

The indicator of item number 1 is the student can identify the element of a circle. Student number 1 understands the concept of the element of a circle because he/she was sure and correct in answering tier-1 and tier-3. Student number 2 has a misconception in identifying the element of a circle because he/she was sure and wrong in answering tier-1 and tier-3. Student number 3 has a partial understanding of identifying the element of a circle because he/she was sure and right in answer tier-1, but he/she was unsure with his/her wrong answer in tier-3.

Discussion

In instructional, diagnostic testing is one type of test. It is also called the analytical test. Teachers use this test to obtain evidence that details a learner's progress on a given subject (Adom, Mensah, & Dake, 2020). In this study, 20 items of a four-tier diagnostic test were developed. After experts judged its validity, it was tested on 34 students. 80% of items are moderate, and 20% of items are too easy. The Dif-I of these (too easy) items is close to the ideal category. Their Dif-I spread from 0.75 to 0.80. The ideal Dif-I is between 0.3 to 0.7 (Musa et al., 2018).

Theoretically, too-easy items are less informative. This is because all students, both those with high and low abilities, answered the questions correctly. As a result, these items do not discriminate well between students' abilities (small difference). Items that are too easy or difficult tend to have poor discriminant power (Musa et al., 2018; Quaigrain & Arhin, 2017), although it may not always be like that (Hingorjo & Jaleel, 2012). In this test, item numbers 3, 11, 13, and 17 tend to have low discriminating power (0.20, 0.43, 0.38, and 0.32, respectively). Because the tests developed are diagnostic tests to identify student strengths and weaknesses and diagnose student misconceptions, they can still be used because they provide information on student strengths.

The consistency of the measurement results of these items is shown by the reliability coefficient obtained from estimation using the Cronbach Alpha formula. In the social, behavioral, and educational sciences, it stands for the most widely used indicator of internal consistency. It is usually interpreted as the average of all possible split-half coefficients (Mohajan, 2017). The test reliability coefficient is 0.72. This exceeds the minimum criteria for the reliability coefficient set by experts. The expected reliability coefficient is at least 0.8 (Quaigrain & Arhin, 2017), 0.5 (Gugiu & Gugiu, 2018), or 0.6 (Rudner & Schafer, 2002). Studies on the meta-analysis of the reliability coefficients reveal that the average reliability of published studies is only about 0.75, with a reporting coefficient of 75% greater than 0.70, a reporting coefficient of 49% greater than 0.80, and only 14% reporting coefficient greater than 0.90 (Peterson, 1994). It indicates that the diagnostic test developed gives consistent measurement. It means that an observed score for a measure actually matches its true score (Mohajan, 2017).

The test was also responded either by students as test users. They stated that the test instructions are easy to understand. The language used in the items is appropriate with their age and daily language. It is important because test questions must use language that is complies with the language used in learning (Clay, 2001) so that it is easy to understand so that they can understand the meaning of the problem.

Regarding the time to do the test, Haladyna's study in 2002 reviewed 27 psychology textbooks and 27 research on the taxonomy of multiple-choice texts, showing that there were no references that mentioned the ideal time to take the test (Brothen, 2012). Because it was developed in Indonesia, the time is adjusted to the time that is often used in national mathematics exams, 4 minutes for the one-tier type. Because this test is four-tier where students still must determine the level of confidence in answering, choosing reasons, and determining the level of confidence, the test developers added 2 minutes. Thus, the time to work on one test item is an average of 6 minutes. For 20 items, tester provides 120 minutes. Most of the students state that the time allotted sufficient for them to complete the test.

The pictures on the test are also presented clearly, and the number of test items is enough for them so that the concentration of students to do the test is stable. Based on this information, the diagnostic test developed is ideal for wider implementation to diagnose students' misconceptions of circle material. Identification of student misconceptions and their sources will assist teachers in overcoming and planning appropriate learning for their students (Ojose, 2015).

Using this test, the level of student’s understanding of circle material can be identified based on the student's responses. Because each item represents the indicator of the competency measured, the analysis reports the level of their understanding of the indicator related.

Implication

This four-tier diagnostic test will help mathematics teachers at junior high schools in Indonesia to identify their students' level understanding at circle material. Whether they understand the concept, do not understand the concept, have partial understanding, or have misconception. For the students, it can be used to evaluate their comprehension of circle material. For the parents, its result will give information about their child's strengths or weaknesses in circle material. This report can be used as a consideration for following up by providing programs, for example by giving enrichment or remedial program. For the following research, this type of test can be developed for the other material in mathematics or other subjects.

Limitation

This study was only tried on 34 students from one school in Yogyakarta. If the participants came from more schools, the data would be more representative to get information on the test. From the aspect of the validity of the test, although it has been analyzed by three experts, it would be more valid when the experts are more.

CONCLUSION

The product of this development research is a four-tier diagnostic test for the circle material of junior high school students in Indonesia. The test consists of 20 items. It has been validated by three experienced experts in the field of mathematics learning. Of the 20 test items, on average, they have an ideal level of difficulty and have a good discrimination index. The consistency of the test is indicated by the reliability coefficient of 0.72. It was estimated using the Cronbach Alpha formula. Students as test users stated that the tests developed contained easy-to-understand instructions, easy-to-understand language, sufficient test time, clear pictures, and enough items.

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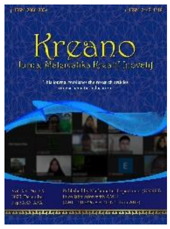
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 386-400



Exploring The Application of The Radec Learning Model (Read-Answer-Discuss-Explain and Create) in Improving Collaboration Skills of Low-Able Mathematics Students: A Case Study

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Abstract

Collaboration in learning mathematics is very important, in everyday learning the teacher does not settle for collaborative learning. At SMA TRI SUKSES itself the learning process is still only focused on the critical thinking skills of each individual student. So that the attractiveness of the students' mathematical abilities is still very visible. This study explores how a teacher implements learning interventions in the classroom and sees how students' abilities develop and looks at students' responses to applied learning. In this study I explored high school students in class XI SMA TRI SUKSES Lampung. - 34 male and female students, determined 4 students with the lowest mathematical ability to be observed and involved a teacher in the observation Using the RADEC learning model. Data collection was carried out through interviews, reflection on the teacher's journal, classroom observations, and learning observations by collecting data qualitatively using a purposive sampling technique in two trials. From the observation results, the application of the RADEC model was quite capable of helping students improve their collaborative skills, initially these low-ability students could only be silent and bowed during the collaboration process in learning, after the model was applied in a fun way and good motivation from the teacher and a group of students with low mathematical abilities seemed to have developed in their collaborative skills so that it affected students' mathematical and cognitive ability scores, which were originally an average of 76.75 and 79.5 to 80.25 and 82.5.

Keywords: RADEC; collaborative skills; intervention

Information of Article

Subject classification	*97C10 Comprehensive works on psychology of mathematics education*
Submitted	*7 June 2023*
Review Start	*9 June 2023*
Initial Review Finish	*9 June 2023*
Round 1 Finish	*22 June 2023*
Round 2 Finish	*9 July 2023*
Round 3 Finish	*7 August 2023*
Accepted	*7 August 2023*
Published	*1 December 2023*
Similarity Check	*7%*

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Abstrak

Kolaborasi dalam pembelajaran matematika sangatlah penting, dalam pembelajaran sehari-hari guru tidak terpaku pada pembelajaran kolaboratif. Di SMA TRI SUKSES sendiri proses pembelajaran masih hanya terfokus pada kemampuan berpikir kritis setiap individu siswa. Sehingga daya tarik kemampuan matematika siswa masih sangat terlihat. Penelitian ini mengeksplorasi bagaimana seorang guru melaksanakan intervensi pembelajaran di kelas dan melihat bagaimana kemampuan siswa berkembang serta melihat respon siswa terhadap pembelajaran yang diterapkan. Dalam penelitian ini saya mengeksplorasi siswa SMA kelas XI SMA TRI SUKSES Lampung. -Siswa laki-laki dan perempuan sebanyak 34 orang, ditentukan 4 orang siswa yang kemampuan matematikanya paling rendah untuk diamati dan dilibatkan seorang guru dalam observasi tersebut. Menggunakan model pembelajaran RADEC. Pengumpulan data dilakukan melalui wawancara, refleksi jurnal guru, observasi kelas, dan observasi pembelajaran dengan pengumpulan data secara kualitatif menggunakan teknik purposive sampling dalam dua kali uji coba. Dari hasil observasi penerapan model RADEC cukup mampu membantu siswa dalam meningkatkan kemampuan kolaboratifnya, awalnya siswa berkemampuan rendah ini hanya bisa diam dan tertunduk pada saat proses kolaborasi dalam pembelajaran, setelah model diterapkan dengan cara yang menyenangkan dan motivasi yang baik dari guru dan kelompok siswa yang kemampuan matematikanya rendah nampaknya telah berkembang dalam kemampuan kolaboratifnya sehingga mempengaruhi skor kemampuan matematika dan kognitif siswa yang semula rata-rata 76,75 dan 79,5 menjadi 80,25 dan 82,5.

INTRODUCTION

From a didactic point of view in mathematics, learning difficulties or disabilities in mathematics are very important because they are related to educational inequality (Deruaz et al., 2020). Barriers to learning mathematics make it difficult to access and participate in various learning activities, therefore, teachers must find ways to support groups and give them equal opportunities to learn mathematics. This study is to introduce and show how interventions to support students with difficulties can help with learning difficulties in mathematics. This study focuses on developing 21st-century skills, namely student collaborative skills. collaboration skills are the skills of working together between two or more students to solve a problem by sharing responsibility, accountability, organization, and roles to achieve a common understanding of the problem and its solution Ahmad, 2018; Da Fonte & Barton-Arwood, 2017; Davis et al., 2018; Dooley & Sexton-Finck, 2017). In line with the opinion above, (Tuti & Mawardi, 2019) Collaborative Skills is a group learning process in which each member contributes information, experiences, ideas, attitudes, opinions, skills, and abilities to jointly improve mutual understanding among all members. Collaboration skills play a role in bringing people together to achieve a better life. Since the world is changing rapidly and thousands of people around us have different opinions and perspectives on different topics, students should familiarize themselves with these skills as early as possible.

The teacher explains material, students take notes, students ask if the material is not understood, the teacher gives assignments, and students read textbooks before the exam. Who knows this move? Yes, teachers must also be creative in using media, strategies, methods, and learning models, or to develop students' collaboration skills. Using various methods and models is more attractive to students because they can stimulate the learning process and can match student learning styles by absorbing learning material (Lestari et al., 2021; Unaenah & Rahmah, 2019). Seeing these problems Innovative learning models to instill and grow students' abilities. That's why it is proposed that the government use various foreign innovative learning models in learning activities. However, it is difficult for teachers to apply this learning model in practice. So that the learning process does not change. the big one. Until now, Indonesia has not been satisfactory either in the fields of mathematics or science in nature and in the field of reading (Pratama et al., 2019). The results of comparative research in international forums indicate that so far there has been no learning that has been able to equip students with the various skills needed at this time. The results of the comparative studies also show the need for improvement in the learning process in Indonesia.

This research study was carried out at SMA TRI SUKSES, NATAR, LAMPUNG. This school was chosen after conducting discussions with the teacher who taught mathematics at the high school, where he experienced difficulties in improving his mathematical abilities at school. Previously students were taught using lecture methods and demonstration methods where the two methods are not sufficiently capable of helping low-ability students to be motivated towards the learning conveyed by the teacher in the classroom, so the teacher needs a method that will stimulate low-ability students' motivation so that they can pay more attention to the learning delivered in front of the class.

According to Sopandi (2019), the learning model from outside experts is an excellent learning model for the 20-21 century, but when applied in Indonesia it is sometimes not to the problems faced by education in Indonesia and the teaching staff will certainly have difficulty adjusting to the educational culture. which is applied to Indonesian students. Because Sopandi (2017) provides another alternative to the learning model and adapts more to the problems of education in Indonesia, namely the RADEC learning model *(read-answer-discuss-explain-create)* Sopandi et al (2019), argues that the RADEC learning model has certain learning characteristics that can strengthen not only conceptual understanding. These features include: 1). RADEC learning model can encourage Students actively participate in learning activities. 2) The Stimulating RADEC learning model independent learning in students. 3) RADEC learning model can contextualize something students know with what material they learn, 4) the RADEC learning model can connect what teaching materials are learned by applying them in real life, 5) the RADEC learning model emphasizes learning student-centered, creating active learning by asking questions, discussing, giving opinions and drawing conclusions related to the topic being studied,6) the RADEC learning model provides an opportunity for students before learning the task before learning to understand. First, study the material in depth.

Studies related to the application of the RADEC model have been carried out by a number of researchers recently, among the results of the research conducted, namely: the use of the RADEC model can increase mastery of the concepts of science subjects: the human breath (Setiawan et al., 2020), improve critical thinking skills in material the nature of light (Karlina et al., 2020) and in the Indonesian context (Pratama et al., 2019), improve creative thinking skills and higher order thinking in energy learning (Sopandi, 2017) and develop cooperation and communication skills (Sukmawati et al., 2020), Application of the Radec Learning Model in Designing Cultural Diversity Learning Activities in Grade IV Elementary Schools(Fuziani et al., 2021), the effect of the read answer discussion explain and create (radec) model on thematic learning on student learning outcomes moderated by learning motivation (Halim, 2022), radec as an Innovation Model of Islamic Religious Education Learning Post the Covid-19 Pandemic in Elementary Schools (Iwanda *et al*., 2022), the radec learning model (read, answer, discuss, explain, and create) from the perspective of forming a Pancasila student profile(Sutantri et al., 2023)the application of the radec learning model to improving students' critical thinking skills(Yulianti, Lestari, Rahmawati, et al., 2022), A group learning process in which each member contributes information, experiences, ideas, attitudes, opinions, skills and abilities to jointly enhance mutual understanding among all members. (Pratama et al., 2020).

Some of the studies above show that the RADEC model is very effective in increasing mastery of concepts, as well as critical and creative thinking skills in developing cooperative and communicative attitudes in students. However, this research has limited research conducted only on certain subjects at the elementary level, therefore this study will explore the application of the RADEC learning model to class XI high school students in developing their collaboration skills.

The following is RADEC. learning model syntax (Pratama et al, 2019) namely:

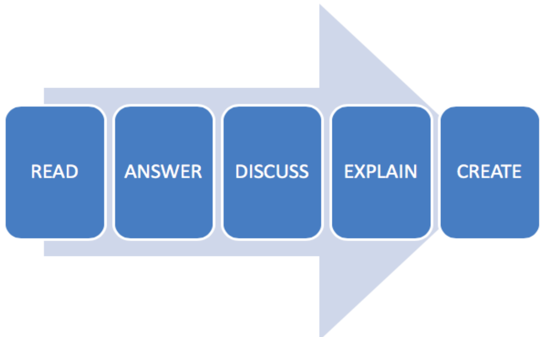

Figure 1. RADEC learning model syntax.

The steps in the RADEC learning model as follows (.

Table 1. RADEC modeling steps

Learning Stage Activity	
READ/read	
Educator	Learners
1. Equipping students with questions that are appropriate to the material to be studied at the upcoming meeting.	1. Exploring information from various sources, both books and print sources such as via the internet.
Answer	
1. monitoring and motivating students toreading and doing Assignments	1. answer learning Questions
Discuss	
1. Motivating students who are successful in carry out certain tasks to guide friends who didn't get it. 2. Motivate students who have not mastered to ask a friend or teacher. 3. Ensure communication between participants educate 4. Look at the group or who hasn't master the concept being studied.	1. Discuss in groups Answers to statements or assignments that have been worked on or discussed to the teacher.
Explain	
1. Confirm what the presenter explained correctly (if group work) and the teacher himself scientifically and all students understand that explanation. 2. Encourage other students to ask questions, refute, or add to what is already delivered by his friend and argued what was explained by the teacher. 3. Explain the essential concepts that have not been able to Mastered by students.	1. Students explain the Concept essential skills that he has mastered in front of the class or arguing directly with the teacher
Create or create.	
1. Inspire students to tell stories creative ideas or thoughts 2. Guiding students to realize ideas creatively, make reports and report them	1. Discuss creative thinking what they have thought about independently or with friends 2. Discuss ideas to Realize Right, make a report and report it

METHOD

This research uses a case study design study to collect relevant qualitative data. This case study study was chosen because the researchers wanted to investigate whether the syntax of the RADEC model used had an impact on low-performing students, especially when learning mathematics. This research was conducted on class XI students of SMA TRI SUKSES, NATAR, LAMPUNG. A two-tried purposive sampling technique was chosen where Merriam and Tisdell (2016) stated that qualitative case studies require purposive sampling at two levels when it comes to general questions whose interests are illuminated by an in-depth study of specific events. In this study I screened students of class XI IPS, which consisted of 17 male students and 34 female students. these students obtained 4 students with the lowest average cognitive abilities and skills, namely:

Table 2. Cognitive abilities

Name	Average Value	KKM	Another average friend
S1	77	75	80
S2	77	75	80
S3	76	75	80
S4	77	75	80

Table 3. Students' mathematical skills

Name	Average Value	KKM	Another average friend
S1	80	75	82
S2	80	75	82
S3	78	75	82
S4	80	75	82

By observing students who have cognitive abilities and mathematical skills, it turns out that we can see how the collaboration skills of these students either collaborate with the teacher or with other friends because collaboration skills are one of the supporting factors for success in getting good grades in cognitive skills and students' mathematical skills.After determining the students with the lowest average results or scores, then asking for collaboration with the homeroom teacher who handles these students, by collecting data through interviews, journal reflection and observing the worksheets of the four students and conducting class observations to see the collaborations carried out by the four students with other friends.The purpose of this study aimed to explore the use of the RADEC learning model on the development of cooperative skills of the weakest students and to explore the impact of using the RADEC learning model and exploring Solve or answer the following research questions: (1) How do teachers apply the RADEC learning model in the mathematics learning process? (2) Can the RADEC learning model develop the collaboration skills of students with the lowest mathematical abilities?

Data collection and analysis data for three weeks of intervention. We checkReflection on the teacher's journal, observing the process of learning activities, observing low-ability student worksheets, triangulation with lesson observation data and In-depth interviews to ascertain the influence of the RADEC learning model. Reflection on this journal used as the primary data of this study the class teacher wrote his journal reflection after he did lesson. Anecdotal notes and pictures taken during observation. Data sources are very important to see interactions between students and their progress in learning. After class observation, in-depth interviews were conducted to enable the teacher to do so to reflect on his experiences implementing the intervention and to explore his perceptions of the learning methods used.

Data from journal reflections, interview transcripts, and anecdotal notes were analyzed. Categories are made based on indicators that emerge from the considered journal entries relevant to the research question. In the second step, interview data transcribed from anecdotal records. In the third step, data from the teacher's reflective journal, interview transcripts, and anecdotal notes of class observations compared and observed. In the final step, we evaluate the reliability of the theme by re-reading and re-analyzing the concept of learning methods to ensure the accuracy of the findings.

Data Collection and Analysis

The data were obtained from the results of in-depth interviews with Mrs.AN, looking at the results of the curriculum assessment that had been carried out by Mrs. Ani, observing class learning, seeing the work of the four students with low abilities, then triangulating the learning data and interviews.

After seeing the results of interviews, observations, and the work of the four students, then carry out relevant analysis in the application of the RADEC learning model and try to carry out the steps in implementing the learning model. The learning intervention using RADEC is carried out with several themes of learning mathematics and looking back at the results. interviews and observations were made of Mrs. Ani and the students as well as class observations to see if there were any new questions in applying the model. The RADEC learning model intervention process was carried out for 6 mathematics learning meetings at school.

RESULTS AND DISCUSSION

Results

After conducting various analyses new questions arise, namely: (1) Is the RADEC learning model suitable for low-ability students to improve their collaboration skills among other students who are far more active than the four students?

At this stage or section, the focus will be on the teaching process that will be performed by Ms. Ani by applying RADEC learning model. Describing the case and clarifying how she applies the steps in the RADEC learning model in class, it mainly focuses on students with mathematical abilities.

The results of the research at this stage are to answer questions in research problems with RADEC modeling which focuses on the mathematical development of low-ability students in some mathematics subject matter with five stages specifically: Read-Answer-Discuss-Explain-Create

Read

At the reading stage the teacher orders to read about the math material that will be studied at the next meeting, namely derivative, exponential, and logarithmic material,teacher encourages or motivates students independently to look for a case study design study to collect relevant qualitative data for the next lesson where at this stage all students are instructed to look for lesson profiles with predetermined themes either from books or other print media and by utilizing the internet. After the students have read, at the next meeting, reflect on the material they were assigned to read.

Help students understand information provided in pre-course questions. The pre-instruction questions are questions related to the topic. Preschool questions should include a variety of questions from low to high thinking skills According to Pratama (Pratama *et al*, 2019).The lesson, questions are asked before the teacher completes the learning based on the teaching material.Students must answer the questions after reading practice. Students carry out reading activities independently outside the classroom. It is based on the idea that students can master some information on their own and without the help of others. Subject matter that is not yet known to students can be explained to other students or the teacher can explain it during learning.

Answer

In this step students answer questions about preschool education from the teacher. The developed pre-learning questions incorporate concepts from topics presented in students' reading materials during the reading phase. The teacher encourages students to answer pre-class questions based on the information obtained at the reading stage(Yulianti, Lestari, & Rahmawati, 2022). The teacher's preliminary questions are used to develop students' understanding of the reading and concepts being taught, allowing students to provide simple explanations (primary explanations) about the topics read and explained. A simple explanation (basic explanation) is an indicator of critical thinking skills. Also at this stage, students practice cultivating Spontaneity and autonomy in finding answers from the sources they are reading (Setiawan et al., 2020). In addition, using these study questions, teachers can collect, and rank concepts based on students' answers, giving them an idea of how well they know. (Lestari & Widodo, 2021).

In the answer stage, usually, after students have read and searched for the theme of the material given by the teacher, which was carried out independently outside of school, they will answer the questions that were given at the previous meeting, then they will answer on a worksheet and the teacher will see how far their knowledge of material to be studied. During the observation of this study, I asked Ibu Ani to ask students to answer questions in turn facing the teacher, because to be able to see the interactions and activities of low-ability students in answering questions. So, at the answer stage, Ibu Ani asked students to answer the questions randomly by lining up in front of the class according to the theme of the material given the previous week.

At this stage, Mrs. Ani asked students to state their search results by reflecting on the results of their searches outside of school on the mathematics subject matter to be studied and answering questions that had been made according to the students' searches that they had made in the worksheets. This also aims to motivate students with low abilities so they can be active and independent in the learning process, so they are not left behind with other friends.

Figure 2. Students answering questions

When interviewing Ibu Ani in this process, she explained:

"at this stage before starting the lesson, I made a game by asking questions according to the theme that I had conveyed in the previous meeting (namely reading and studying the material according to the read stage). I did this according to the stages in the RADEC learning model to see where knowledge of students, especially students who are identified with low ability in mathematics, namely where students who can answer correctly will get a reward at the end of learning.

Mrs.AN further explained:

"The students looked very excited about what I was saying, as well as the 4 students who were studied with low mathematics abilities. However, if you pay attention, if the other students are excited and even want to start the game immediately, the four students tend to be shy in their expressions and deliver the answer."

At the answer stage, the method that has been applied by Mrs.AN is enough to make students more motivated in finding out or reading the material to be studied. Not only does it affect students with good math skills, but it also has a positive impact on students with low abilities. Of the four students who were previously in the learning process before the application of the RADEC model who tended to be more silent and only listened to their other friends, after being required to participate in answering questions these students showed progress in interaction. tend to be afraid when answering the questions given. This is very good for the next learning process were increasing the motivation of the teacher and his friends and giving the same room as other students will certainly greatly help improve the collaboration skills of these low ability students.

Discussion

During at this point, students discuss the answers to questions in groups. At this point, students can discuss their answers with other members of the same group. At this point, the teacher must ensure that there is an exchange between the students in each group to get the correct answer. By observing the group's activities, teachers also find out which groups do well in the subject they are studying. This also allows the teacher to find out which group or groups have creative ideas to apply concepts being studied (Pratama *et al*, 2019). The teacher divides students with different cognitive abilities into groups of smart, active, passive, and thrifty students. The teacher is all students in the group participate in the discussion.In the discussion stage, students' knowledge and thinking skills are further trained and developed. This phase stimulates indicators of critical thinking to build basic skills (basic support) and draw conclusions (Satria & Sopandi, 2019).

The group discussion process is not only carried out in the classroom as well as outside the classroom, but this is also intended so that students can further explore their creative ideas in solving the problems of the material to be worked on. During the discussion process students can not only discuss among themselves in groups only but also can discuss directly with the supervising teacher regarding the obstacles in the problem solving process.

In the discussion process, Mrs. AN divided the groups based on gender because she considered the comfort of low-ability students who sometimes still looked confused and shy and combined with students who certainly had different characters so that the discussion process was more continuous, and it could be seen how students' collaboration skills developed. Gender grouping was carried out. with the psychological considerations of students, where students at their age tend to have sensitive feelings when they must deal with the opposite sex so they are afraid that increasing their motivation in arguing during discussions will hinder. Because sometimes teenage students when dealing with the opposite sex feel awkward.

When we made observations when the discussion process was carried out, we saw how the collaboration skills of each group that had been made, there was still a very visible gap between students who actively interacted and students who only listened quietly.So that with the above conditions these students need growth motivation, where growth motivation or metaneeds encourages students to realize their potentials(Meliala, Timoteus S.; M.Sastrapratedja,supervisor;Soerjanto Poespowardojo,1988).At this stage, it can be seen that low-achieving students find it difficult to show their contribution from their point of view. In fact, when given their motivation to answer questions about derivatives, they seem ambiguous and tend to fear being wrong. These children who are bad at math often keep their heads down and smile only when talking to other children in the class. These children must be motivated first so that they want to give their opinion and the encouragement of their peers to want to speak up in the discussion.

Figure 3. during the student discussion process

Because there are still visible gaps in the discussion process, Mrs. Ani tries to Encourage students to read and complete the assignment. Encourage students who succeed on specific tasks to mentor their unsuccessful friends, motivate students who do not master to ask their friends or the teacher, ensuring communication between students, and paying attention to groups or those who have not mastered the concept being studied so that each student's collaboration skills are successful and work properly and forcing low-ability students to want to participate in the discussion process.

After the motivation was given to these students, we could see developments in the discussion process where students who were initially more interactive provided motivation and space for students who seemed hesitant to convey ideas of course in a friendly way so that these students would not feel pressured and give appreciation for the ideas he has conveyed. So that communication in discussions runs continuously and group collaboration goes well.

After learning we interviewed Ani's mother regarding this discussion process:

"During the discussion process I formed groups with various abilities and characteristics of students, to see collaborative interactions between groups. At first, the individual student tendencies were far more prominent than the collaboration of each group, but after being motivated to work together and motivating students who seemed to only be silent to participating it turned out that the discussion ran smoothly and was able to find ideas in solving material problems in mathematics and of course taking into account student psychology so that the delivery of ideas was not pressured and of course fun for all students."

At the discussion stage by motivating students to collaborate with each other it turned out to be enough to help students slowly improve their students' collaboration skills, especially the four students who had low ability scores. , after being motivated and appreciated by other friends, the two students looked doubtful and shy just like they were holding answers. However, the other two students developed quite well by showing collaborative interactions, even though it was still in a very minimal portion.

Explain

At the explain stage, students are given the opportunity to demonstrate the results of their discussions related to the learning theme material provided by the teacher. Here, representatives of students who have studied indicators of learning explain key concepts to the class. In this activity, Teachers also provide that the instructor's causes are scientifically correct and accepted by other students. In this activity, the teacher also encourages other students to ask questions and debate or complement the words of their friends from other groups and help friends who are presenting prepare the required components. At this stage, the teacher can also use it To explain important concepts that not everyone understands. The student specified in the discussion step. When explaining, teachers can explain with illustrations, videos,

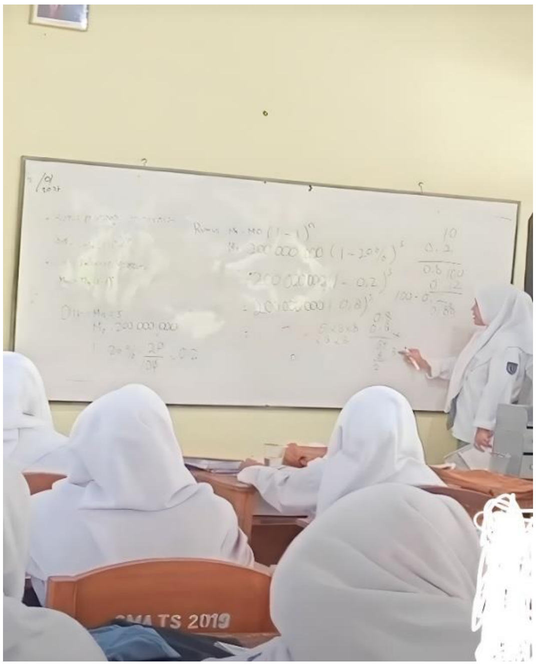

Figure 4. when students demonstrate the results of the discussion

When carrying out the demonstration results of the discussion I analyzed the role of students with low mathematical abilities, where the development of collaboration which was shown from the interaction during the presentation process was developing quite well. In which, these students who were initially afraid, doubtful, and seemed shy began to open and are willing to speak out in conveying the results of their discussions and are willing to help their friends who are demonstrating in demonstrating and answering questions from other group mates even though their answers are still very minimal and sober. However, here it can be seen where with a good motivational approach, collaboration between students and teachers who do not show favoritism is enough to help low-ability students to develop in improving their collaboration skills. In fact, not only developing collaboration skills, at this stage it turns out that students' cognitive abilities and mathematical skills show quite good changes.

Create

At this stage, teachers help students learn how to use the acquired knowledge to develop ideas or creative thinking. Creative thinking can be formulated as questions and problems, or productive thoughts about the creation of other creative works. As in the previous read and answer stages, pre-class questions are about generating creative ideas or thoughts for students after independently studying the material provided. Inspiration provided by teachers can come as examples of research, problem solving, or other work done by people. They then discuss more creative ideas they can add and implement. As an additional source of inspiration for students, teachers can give examples of creative plans that neither they nor others realize, depending on the type of development, ideas can be implemented. Present alone or in a group. Because of the original idea, this job is theoretically more difficult for students, in addition, the idea can be implemented successfully or unsuccessfully. Moreover, the implementation of the idea can be inside or outside the classroom, it can be short or long. During this point, dominant students are trained to think, work together, and communicate. He learns to find creative ideas, implement ideas, plan implementation, implement plans. Due to original ideas, this work is theoretically a greater challenge for students, besides, ideas can be implemented successfully or unsuccessfully. Moreover, the implementation of ideas can be done inside or outside the study hall and can be short or long. At this point, dominant students are trained to think, collaborate, and communicate. He learns to find creative ideas, execute ideas, plan execution, and behead plans. Because of the original idea, this effort is theoretically a higher challenge for the student, and the implementation of the idea can be successful or unsuccessful. Moreover, the application of intelligence can take place inside or outside the classroom and can be short-term or eternal. At this stage, dominant students are trained to think, participate, and communicate. He learns to find creative ideas, implement ideas, plan implementation, implement plans.

At the create stage, Ani tries to ask her students to implement their creative ideas in groups to see the further development of low-ability students in exploring their collaboration skills and to see the progress of these students in understanding mathematics learning.

Table 4. The value of students' cognitive abilities and mathematical skills after applying the RADEC model

Name	Students' cognitive value Before deployment the RADEC model	Students' cognitive value after implementation the RADEC model	Skill value Students before the What are the RADEC models	Skill value Students after the what is the RADEC model
S1	77	80	80	82
S2	77	81	80	82
S3	76	80	78	82
S4	77	80	80	84
	76,75	80,25	79,5	82,5

Figure 5. Students explain the results of creative ideas in learning mathematics.

In this last stage, quite good developments were carried out by students of class XI IPS SMA TRI SUKSES, students were able to demonstrate their collaboration skills quite well, starting from compiling creative ideas that had been designed and poured into an application or media. It is also very expected that the four students with the lowest mathematical abilities can be seen starting to be able to interact and participate quite well in composing creative ideas. This was also conveyed by Ms. Ani during the interview session:

"It's really very proud when I see all my students can interact and collaborate quite well in compiling creative ideas in solving problems in mathematics, of course this learning model in my opinion is quite relevant to be applied to my students because it is continuous with the learning problems that I face."

After all the steps for implementing the RADEC learning model are implemented by considering the results of observations, interviews, and developments in the value data of students with low ability in mathematics after applying the RADEC learning model as follows: from the data above, we can conclude that improving students' collaboration skills using the RADEC learning model can actually play a role in improving the cognitive abilities and mathematical skills of students who initially have low scores or mathematical abilities.

Discussion

in this study the application of the RADEC learning model can improve students' mathematical collaboration skills, where increasing student collaboration skills also affects students' cognitive abilities and mathematical abilities, where the scores of low-ability students are initially only at 76.75 points to 80, 25 as well as points and 79.5 becomes 82.5.

ompetence collaboration is the ability to work together and share responsibilities and roles to achieve common goals related to a problem and its solution (Davis et al., 2018; Fitriyani et al., 2019). In the learning process, students must have collaborative skills because they are useful for supporting learning (Ulhusna et al., 2020). Students with collaborative skills may simultaneously make individual contributions at different times or in different places, or separately from other group members (Falcione et al., 2019).

In this study, after all stages of the RADEC learning model were applied in improving students' collaboration skills, the design of this model must have specifications for more accurate implementation steps, because when conveyed to educators regarding the application of this model we have to re-design how the learning process takes place in accordance with The steps given. This study also found that in the discussion stage educators must have a motivational design that will build their students' collaboration skills by considering the psychology of low-achieving students when expressing ideas and creative thinking and motivating and monitoring other students so they can collaborate and help guide students who do not understand the concepts being studied.

Implication

In subsequent research with the use of the radec learning model, especially the application of learning to high school students, consideration of student character and problems in learning must certainly be given more attention, because where every step in this learning model every student is required to be initiative and collaborative in solving problems and creating creative ideas in completing the tasks given. Thus, data collection techniques using two-tried purposive sampling are one technique that is suitable for use, because researchers can detect certain implications in students before the learning model is applied so that the results, we expect at the beginning of the study are appropriate.

Limitation

In this study, of course, there are still many limitations, such as the sample size and research focus which is still relatively narrow, and the processing and observation of the data used is still not optimal and the constraints of student psychology in interactive which of course must make the planning process of implementing RADEC modeling must be more creative and innovative when applying the learning model. However, if all steps can be carried out properly, of course, this modeling has the potential to develop students' collaborative skills.

CONCLUSION

Applications of the RADEC learning model to high school students with low abilities can stimulate collaborative interactions if the steps are implemented according to design and apply them innovatively. The RADEC learning model can be one of the solutions that can be applied by teachers to improve their students' mathematical abilities, because this model is designed according to with the problems faced by the learning system in Indonesia. The most important consideration is when the implementation of this model can stimulate students' interest in participating in learning, and the steps contained in this model can create abilities evenly among students, where students are required to communicate with each other and collaborate to create creative ideas when solving problems in mathematics.For the development of students who initially had low abilities, with application of the RADEC model improve their collaboration skills, it turned out that with discussions in the modeling students' collaboration skills improved quite well. The thing that was worried about when doing the analysis at the beginning of the study was that these low-ability students it will actually be retarded by other students who are more interactive in fact it can be handled with the motivation given by the teacher and friends, which of course is fun motivation without being cornered.The thing that was feared when doing the analysis at the beginning of the study where these low-ability students would actually be retarded by other students who were more interactive could in fact be handled with the motivation given by the teacher and their friends, which of course was fun motivation without being cornered.The thing that was feared when doing the analysis at the beginning of the study where these low-ability students would actually be retarded by other students who were more interactive could in fact be handled with the motivation given by the teacher and their friends, which of course was fun motivation without being cornered.

By developing the collaboration skills of these low-ability students, it also improves their scores on their cognitive abilities and mathematical skills. Of course, this case study research still has many shortcomings, given the limited sample size and very narrow research focus. However, the implications of the question "*Is this learning model able to improve the collaboration skills of students with low abilities?*"From the case studies conducted, this learning model has the potential to improve the collaboration skills of low-ability students in high school.

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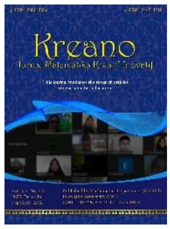
UNNES JOURNALS

Kreano, Jurnal Matematika Kreatif-Inovatif
Volume 14, number 2, 2023, pp. 401-412



Analysis of Students' Proficiency in Mathematical Communication Through the View of Self-Regulated Learning

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Abstract

Changes in the education implementation system during the Covid-19 pandemic force students to adapt quickly. This adaptation occurs because online learning limits teachers ' ability to monitor the overall learning carried out by students. Therefore, in the implementation, students must have Self-Regulated Learning to manage their learning activities independently and analyze their learning needs. In addition, Self-Regulated Learning is also able to provide support for improving various abilities, for example, mathematical communication. This study aimed to determine whether Self-Regulated Learning affects students' mathematical communication skills. The research method used is correlational with a sample of 31 students in grade IX of a junior high school in Serang City. The results of this study indicate that Self-Regulated Learning affects students' mathematical communication skills, with a coefficient of determination equal to 21%. This research can inform educators that Self-Regulated Learning influences students' mathematical communication abilities, so educators must design learning to help improve students' Self-Regulated Learning.

Keywords: *Self*-Regulated *Learning; Mathematical Communication; Covid-19; Effect.*

Information of Article

Subject classification	*97C50 Language and verbal communities (aspects of mathematics education)*
Submitted	*17 July 2023*
Review Start	*7 August 2023*
Initial Review Finish	*22 August 2023*
Round 1 Finish	*23 October 2023*
Round 2 Finish	*23 November 2023*
Accepted	*24 November 2023*
Published	*1 December 2023*
Similarity Check	*12%*

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Abstrak

Perubahan sistem pelaksanaan pendidikan pada kondisi pandemi Covid-19 memaksa siswa untuk beradaptasi secara cepat. Adaptasi tersebut terjadi karena pembelajaran secara online memberikan batasan bagi guru untuk memantau keseluruhan pembelajaran yang dilakukan oleh siswa. Oleh karena itu, dalam pelaksanaan pembelajaran secara online siswa harus memiliki Self-Regulated Learning agar mampu mengatur kegiatan belajarnya secara mandiri dan mampu menganalisis kebutuhan belajarnya. Selain memberi dukungan yang besar terhadap pelaksanaan pembelajaran secara online, Self-Regulated Learning juga mampu memberikan dukungan terhadap peningkatan berbagai kemampuan, salah satunya adalah komunikasi matematis. Penelitian ini bertujuan untuk mengetahui apakah terdapat pengaruh Self-Regulated Learning terhadap kemampuan komunikasi matematis siswa. Metode korelasional digunakan dengan sampel penelitian sebanyak 31 murid kelas IX di salah satu SMP di Kota Serang. Hasil penelitian ini menunjukkan Self-Regulated Learning berpengaruh terhadap kemampuan komunikasi matematis siswa dengan koefisien determinasi yaitu sebesar 21%. Penelitian ini dapat memberikan informasi kepada pendidik bahwa Self-Regulated Learning berpengaruh terhadap kemampuan komunikasi matematis siswa, sehingga pendidik harus merancang pembelajaran yang dapat membantu meningkatkan Self-Regulated Learning siswa.

INTRODUCTION

A disease that attacks the human respiratory system called Covid-19 has been reported in Wuhan, in December 2019 (Ciotti et al., 2020). This disease spread worldwide and affected many countries, so WHO declared Covid-19 as a pandemic in March 2020 (Pokhrel & Chhetri, 2021; Tarkar, 2020). This disease spreads and is contagious in a short time. On 18 April 2020, WHO reported that more than 2.1 million cases of Covid-19 had been confirmed and caused the death of 142,229 people in 213 countries (WHO, 2020).

Covid-19 has also spread in Indonesia. In March 2020, the President of Indonesia announced the first case of Covid-19 infection, which infected two of his citizens. Every day, the number of residents infected with Covid-19 is increasing, so to suppress the spread of Covid-19, the government in Indonesia is implementing physical distancing, one of which has an impact on closing schools, which means that learning cannot be present in classes to prevent the spread of Covid-19 (Rulandari, 2020).

This rule is included in Circular No. 4 of 2020 on implementing education during the emergency period due to the spread of Covid-19, which stipulates that the learning process takes place at home through online/ distance learning. Activities and tasks carried out by students may vary, considering conditions, access, facilities, and student learning interests (Ministry of Culture and Education, 2020).

Learning that is carried out online requires students to organize their learning activities because the teacher cannot be physically present to monitor the activities carried out and cannot provide assistance or support directly (Wong et al., 2019). Therefore, students must have good Self-Regulated Learning (SRL) in implementing online learning.

Self-Regulated Learning (SRL) helps students understand their study habits, get used to self-regulation, and manage time in learning activities (Sudinadji & Kumaidi, 2019; Effeney et al., 2013; Zimmerman, 2002). SRL is an attitude within a person to manage their thoughts, behaviours, and emotions in obtaining learning experiences (Zumbrunn et al., 2011). SRL is essential for students because they will be able to control their actions and be able to control the learning activities, they carry out to achieve success in the academic field (Effeney et al., 2013).

SRL has a relatively stable tendency to respond to various learning situations (Setyaningrum, 2019). It means that in conditions before the pandemic (offline learning), during the pandemic (online learning), and when the pandemic ends (when learning goes offline again), SRL is an essential thing that students need to have. This statement is strengthened by the results of research conducted by Sun, et al. (2018), which shows the importance of SRL in both pre-class Internet-based (online learning) and in-class collaborative learning (offline learning).

In addition to providing outstanding support for implementing online learning, SRL can also support increasing the knowledge competencies students need. The knowledge competencies students need in mathematics lessons are generally included in the mathematics learning objectives presented by the NCTM (2000). The objectives of learning math are to develop the ability to (1) mathematical communication, (2) mathematical problem solving, (3) mathematical connection, (4) mathematical reasoning and proof, and (5) mathematical representation. Based on these learning objectives, mathematical communication is essential to master.

According to Sundayana et al. (2017), mathematical communication is an important ability for students to form concepts, determine strategies, carry out scientific investigations, and a means of communication to obtain and share thoughts and information that can be used as capital for students' success in solving problems. Communication is essential to human life because communication can solve various problems in a person's life, and even communication can improve relationships with other people (Liliweri, 2017).

In the learning process, both offline and online, the teacher must help students develop their communication skills (Rustam & Ramlan, 2017). Baroody (1993) states two important reasons for developing mathematical communication: (1) Mathematics is a language that accurately, clearly, and succinctly communicates ideas. (2) Learning math is a social activity that requires interaction (communication) between teachers and students to develop students' potential in mathematics.

Mathematical Communication Skills (MCS) are a mandatory requirement for students. However, many studies say Indonesian students' mathematical communication skills still need improvement. Ahmad and Nasution (2018) concluded that 40% of students had low categories in MCS. The same opinion was expressed by Wijayanto et al. (2018) The Mathematical Communication Skills of junior high school students are still in the low category. This can be seen in the results of the questions being tested. Based on the explanation, it is necessary to examine mathematical communication skills based on SRL during the Covid-19 pandemic.

Cotton (2008) classifies communication into two: oral and written communication. Oral communication occurs when interactions (dialogues) and discussions occur between students or between students and teachers on the topic being studied, which can help deepen student understanding and help students find mistakes in solving math problems. In contrast, communication through writing occurs when students can use notations, pictures, and words to solve the problems.

Mathematical communication skills that will be studied in this study are written communication skills because the results of student work expressed in writing are essential things that can be a source of information for teachers in understanding how students think (Pugalee, 2001). When the results of students' thinking are put into words, the teacher can adjust instructions and provide support and assistance according to student needs (Back et al., 2010).

METHOD

This research used a nonexperimental research design involving causal relationships that explore cause and effect relationships between variables without using the experimental method (Gall et al., 2010). The research method used in this study is a correlation method with a quantitative approach. This study aimed to examine how SRL affects students' mathematical communication skills.

The population in this research were students in grade IX at one of the junior high schools in Serang City. The sample of this study was 31 students in class IX who carried out online learning for about two years during classes VII and VIII. The material used in this research was SPLDV, taught in class VIII (when learning was still online). This study used 12 questions from a mathematical communication ability test instrument and a non-test instrument in an SRL scale of 32 statement scales, including 16 positive and 16 negative statement scales. Experts have validated all instruments used.

This research was conducted with several stages, including: 1) Collecting data, at this stage, the researcher distributed questionnaires of Self-Regulated Learning and a mathematical communication test. After the students had completed the questionnaire and mathematical communication test, the researcher collected them. 2) Data Analysis, at this stage, the researcher analyzed maximum, minimum, and average scores. Various tests were also carried out using SPSS, including normality, linearity, regression, and correlation tests. 3) finally, the researcher concluded. The research stages are shown in Figure 1.

The indicators used to measure mathematical communication skills were adopted from the indicators presented by Syafina & Pujiastuti (2020) because the mathematical communication abilities measured in this study were the same as those measured in this study (mathematical communication skills for written tests). The indicators used include: 1) writing what is known and required from the problems presented; 2) representing ideas and mathematical situations in the form of symbols or mathematical models; 3) writing down the appropriate calculation operations and writing down the solutions to these problems; 4) make conclusions from the solutions obtained. The Self-Regulated Learning indicator used in this study was adopted from the independent learning indicator that Zimmerman (2002) has conveyed by not including the last indicator, having self-efficacy or self-concept, because this indicator is an active variable that can stand alone. Other indicators can be used because they are an integral part of the self-reliance cycle described earlier, namely planning, monitoring, and evaluation. So, the indicators used include 1) diagnosing learning needs;

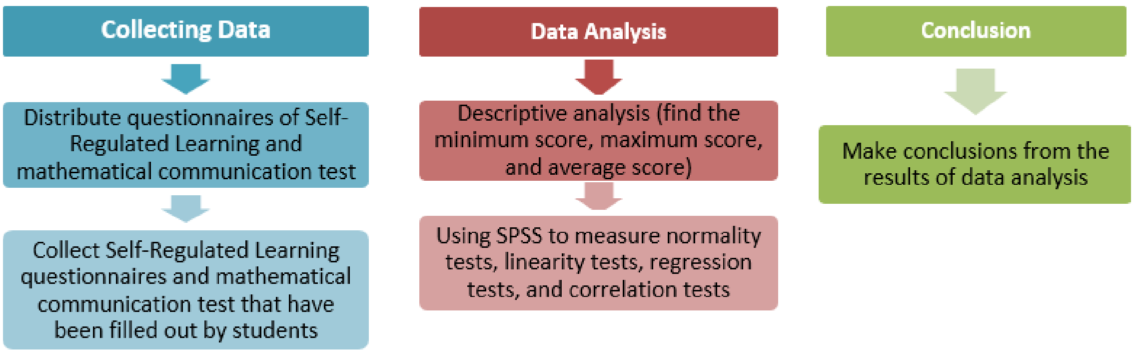

Figure 1. Research Stages

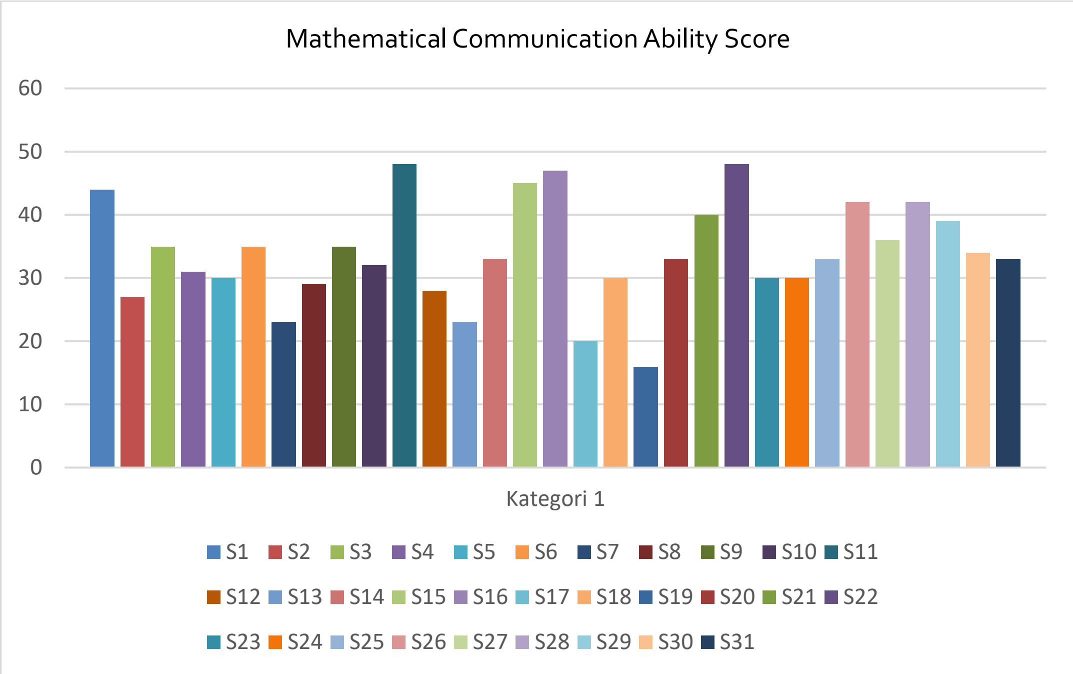

Figure 2. Mathematical Communication Ability Test Scores

2) initiative and motivation to learn; 3) viewing a difficulty as a challenge; 4) formulating learning objectives; 5) selecting and implementing the chosen learning strategy; 6) utilizing and searching for relevant sources; 7) organize, control, and monitor the learning activities carried out; 8) evaluation of learning processes and outcomes (Zimmerman, 2002).

RESULTS AND DISCUSSION

Results

The data analyzed in this research came from mathematical communication skill tests and SRL questionnaire data. The results of acquiring mathematical communication skills are presented in Figure 2 to make it easier for readers to understand and read research data.

The student had a maximum score of 48 and a minimum score of 16 on the mathematical communication skills test. The maximum score students obtained if they answered all the questions correctly was 48. The average score was 33.90, so there were 14 students with scores above the average of as many as 31.

To find out students' Self-Regulated Learning, they were given a questionnaire containing 32 statements consisting of 8 indicators, including: 1) diagnosing learning needs; 2) initiative and motivation to learn; 3) viewing a difficulty as a challenge; 4) formulating learning objectives; 5) selecting and implementing the chosen learning strategy; 6) utilizing and searching for relevant sources; 7) organize, control and monitor the learning activities carried out; 8) evaluation of learning processes and outcomes. The results of students' SRL scores are shown in Figure 3.

The lowest student score in the self-regulated learning questionnaire data calculation is 67, and the highest is 125. The maximum score students in the self-regulated learning calculation can obtain is 128. The average student score is 100.58, so 19 students have scores above average.

Furthermore, various tests were carried out using SPSS to determine whether there was an effect of Self-Regulated Learning on students' mathematical communication abilities. The test performed is

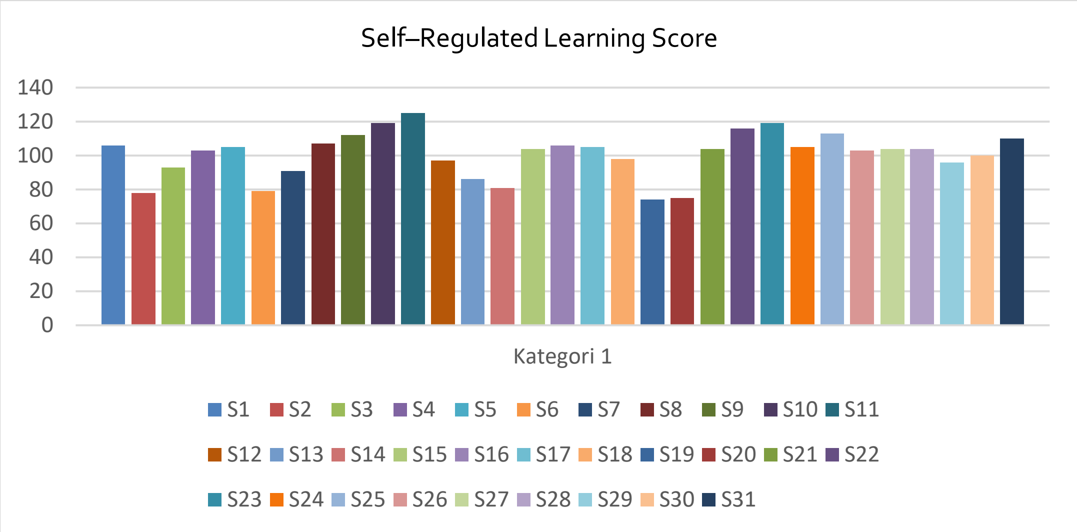

Figure 3. Self–Regulated Learning Score

a regression test.

However, prerequisite tests, including normality and linearity tests, are run before the regression test. The normality test used Shapiro-Wilk in IBM SPSS statistics 26 with α = 0.05. The test results show a significance value for mathematical communication ability of 0.496 and a significance value for SRL of 0.084. The significance values are greater than 0.05, so we can conclude that the two data are normally distributed. Details of the normality test results are shown in Table 1.

Table 1. Normality test results

	Shapiro – Wilk		
	Statistic	df	Sig
Self–Regulated Learning	0,940	31	0,084
Mathematical Communication	0,969	31	0,496

The following prerequisite test is the linearity test. This test determines whether Self-Regulated Learning is linearly related to students' mathematical communication skills using IBM SPSS statistics 26 with α = 0.05. The results of the linearity test are shown in Table 2.

Based on the linearity test results in Table 2, we find a significant deviation from linearity of 0.062. Since the sig value is greater than 0.05, we can conclude that there is a linear relationship between SRL and students' mathematical communication skills.

Once the data are found to be normal and linear, we can do a simple linear regression test (see Table 3). The SPSS output results show a calculated F value of 7.819 with a significance level of 0.009. Since this value is less than 0.05, we can conclude that SRL affects students' mathematical communication skills.

The calculated data are used to construct the regression equation shown in

Table 2. The results of the data linearity test

			Sum of Squares	df	Mean Square	F	Sig
Mathematical Communication * Self–Regulated Learning	Between Groups	(Combined)	1754,293	22	79,741	3,616	,033
		Linearity	410,013	1	410,013	18,593	,003
		Deviation from Linearity	1344,280	21	64,013	2,903	,062
	Within Groups		176,417	8	22,052		
	Total		1930,710	30			

Table 3. Data regression test results

Model		Sum of Squares	df	Mean Square	F	Sig
1	Regression	410,013	1	410,013	7,819	,009[b]
	Residual	1520,697	29	52,438		
	Total	1930,710	30			

a. Mathematical Communication Dependent Var); b. Predictors: SRL

Table 4. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
		B	Std. Error			
1	(Constant)	5,729	10,159		,564	,577
	Self-Regulated Learning	,280	,100	,461	2,796	,009

a. Mathematical Communication (Dependent Var)

Table 4. Based on the calculation, the regression equation is Ŷ=5.729+0.280X. This can be interpreted that if the student's SRL is worth 0, then the student's mathematical communication ability is worth 5.729. In addition, the coefficient of student Self-Regulated Learning is positive at 0.280, indicating a positive effect between student self-regulated learning and mathematical communication skills. Full calculations are shown in Table 4.

Furthermore, a correlation test was also performed to determine the magnitude of the effect of SRL on mathematical communication skills. Based on the tests performed, the magnitude of the correlation/relationship (R) between Self-Regulated Learning and mathematical communication skills equals 0.416. From these results, a coefficient of determination (R square) of 0.212 is obtained, which means that the effect of the SRL on the dependent variable (mathematical communication ability) is 21%. The results of these calculations fall into the interval 0.20 - 0.39 with the low category. In comparison, the remaining 79% of students' mathematical communication skills are influenced by other factors. Complete calculations are shown in Table 5.

Table 5. Correlation value test results

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	,416[a]	,212	,185	7,241

a. Predictors, SRL

Discussion

The calculation results show that SRL affects students' mathematical communication skills. This aligns with the research results revealed by Sulastri and Sofyan (2022) that SRL affects students' mathematical communication skills. So, we must pay attention to the efforts to improve mathematical communication abilities. In line with this opinion, Dalimunthe et al. (2023) stated that students with higher levels of SRL also had better mathematical communication skills. This applies under the best conditions. Students with low SRL also have low mathematical communication skills. Other research that strengthens the results of this research is also stated by Nurhasanah & Zhanty (2019) that SRL positively affects students' mathematical communication abilities by 57.7%.

To analyze the effect of SRL on mathematical communication skills (shown in the results of student work). Figure 4 and Figure 5 are students' an-

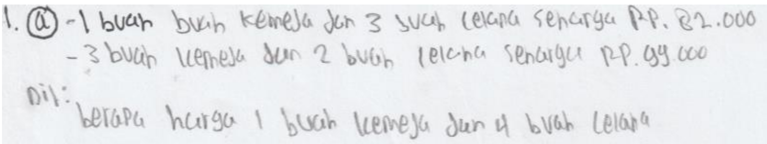
1. (a) -1 buah buah kemeja dan 3 buah celana seharga Rp. 82.000
-3 buah kemeja dan 2 buah celana seharga Rp. 99.000
Dit:
berapa harga 1 buah kemeja dan 4 buah celana

Figure 4. Responses of students with low SRL

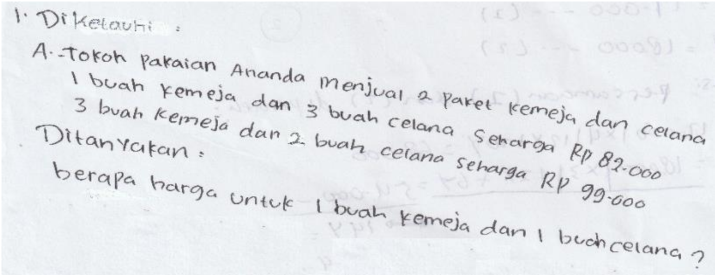
1. Diketahui :
A. Tokoh pakaian Ananda menjual 2 paket kemeja dan celana
1 buah kemeja dan 3 buah celana seharga Rp 82.000
3 buah kemeja dan 2 buah celana seharga Rp 99.000
Ditanyakan :
berapa harga untuk 1 buah kemeja dan 1 buah celana ?

Figure 5. Responses of students with high SRL

swers to tests of mathematical communication skills on the indicators identifying known elements and the sufficiency of the required elements.

Figure 4 shows the responses of students with low SRL levels. Students have been able to identify a small part of the known and asked elements, but these students still need to identify the elements that are asked correctly. Figure 5 shows students' responses in the high Self-Regulated Learning category. In these answers, students can identify and formulate information related to known things and ask questions correctly from the questions presented.

This result aligns with the opinion of Muharomi and Afriansyah (2022) that students with high SRL can understand questions and write down known and asked information. In line with this, Mayasari and Rosyana (2019) argued that students who had to write down what they knew and ask questions about the problem had low SRL. Furthermore, the answers for indicators of planning strategies to solve problems by making representations or constructing mathematical models of problems are presented in Figure 6 and 7.

Figure 6 shows the responses of low-category Self-Regulated Learning students. Students make models not by the questions given. In the first equation, students make mistakes in using variables. The student should have written 3y as a model of 3 pants, but the student had written 3x. The findings in this study are the same as the opinion expressed by Sulistyani et al. (2020) that students with SRL are in a low category, unable to present problems in mathematical models.

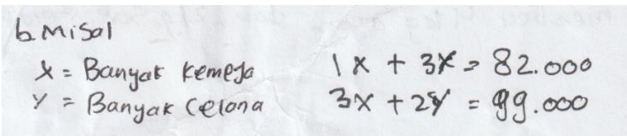
b. Misal
x = Banyak kemeja 1x + 3x = 82.000
y = Banyak celana 3x + 2y = 99.000

Figure 6. Responses of students with low SRL

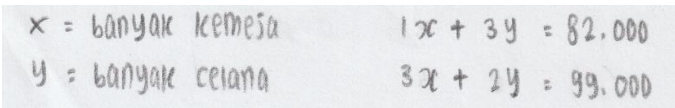
x = banyak kemeja 1x + 3y = 82.000
y = banyak celana 3x + 2y = 99.000

Figure 7. Responses of students with high SRL

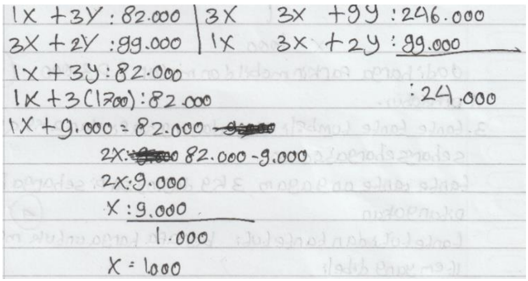

Figure 8. Responses of students with low SRL

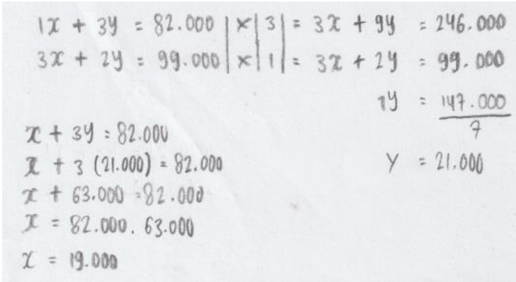

Figure 9. Responses of students with high SRL

While Figure 7 shows the responses of students with high SRL categories, students can make a clear and precise representation or mathematical model of the problem. Students can describe a mathematical situation by changing the existing problems in the problem into a mathematical model. The steps that students take are as follows. First, students make an example of x being the number of shirts and y being the number of pants. Then, students change the problem in a mathematical model, namely x+3y=82,000 and 3x+2y=99,000. Agustiani et al. (2021) stated that students with a high category of SRL could find relationships between variables based on the facts presented in the questions and then create mathematical models based on the information in these questions. Furthermore, the results are presented in Figure 8 and Figure 9 as follows.

Figure 8 shows the responses of students with low levels of SRL. Students have yet to be able to use the elimination and substitution methods to solve the problems. Figure 9 shows that students with high SRL levels can use the elimination method well. This can be seen from the steps taken, namely, students eliminating the x variable by multiplying the first equation x+3y=82,000 by the number 3 and multiplying the second equation 3x+2y=99,000 by the number 1 so that the x variable can be eliminated and produces a value of y=21,000. The students also mastered the substitution method very well. This can be seen from the next step in the previous process, where the value y=21,000 is substituted into one of the equations and produces the value x=19,000. The last indicator, namely re-examining the steps taken and writing down the answers or conclusions obtained on the mathematical communication ability test questions, is shown in Figure 10 below.

Figure 10 shows the answers of students with a high SRL category. In these answers, students can write conclusions correctly. This is different from students with low levels of SRL. Students need to provide answers because they cannot write conclusions from the problems given.

Based on the analysis of each indicator, it is known that SRL affects students' mathematical communication. Ekananda et al. (2020) argue that students with high SRL can understand problems, plan to solve problems, link various concepts to solve problems and draw conclusions from the answers. Arum (2017) conveyed a similar opinion that students with high

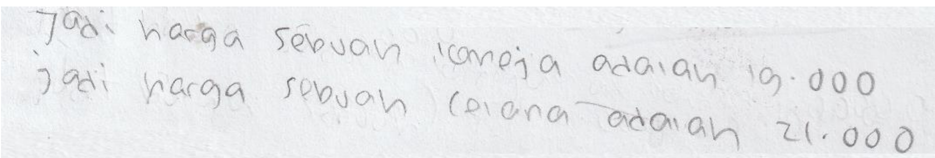

Figure 10. Responses of students with high SRL

SRL can identify problems and information in the questions, design appropriate strategies accompanied by reasons that support the selection of these answers and conclude the results.

This research shows that students with high Self-Regulated Learning can carry out learning activities well despite facing different learning conditions. They tend to adapt to new learning conditions (online learning) quickly and do not require close supervision in learning activities because the learning activities they carry out are based on their inner awareness of the need and necessity to learn. Students with high Self-Regulated Learning have high motivation in learning. When they experience difficulties in the learning process, they immediately look for relevant learning resources such as ebooks, which they can download for free on Google or search for information on YouTube. In contrast, children with low Self-Regulated Learning require close assistance in learning activities. When they face difficulties in solving a problem, they tend to give up quickly and do not have to look for other learning sources to support the learning process.

This is in line with the opinion expressed by Pelikan, et al. (2021) that a learning process requires high levels of Self-Regulated Learning for students. Especially when offline learning is switching to online learning during the Covid-19 pandemic, students with high Self-Regulated Learning can set learning objectives, manage time, and use various strategies that are considered effective in supporting learning activities. Furthermore, they can continue to increase their learning motivation until they obtain assessment results that they feel are high.

Based on this, we can conclude that Self-Regulated Learning is an essential thing that students need to have. So, in any learning situation, whether online or offline, students can learn well without experiencing obstacles.

Implication

The results of this study should inform educators that Self-Regulated Learning influences students' mathematical communication abilities. So, apart from completing learning materials, educators must design learning that can help improve students' SRL. This study is also intended to serve as a reference for researchers wishing to conduct similar research, particularly regarding the impact of SRL on various students' mathematical abilities.

Limitation

Limitations in the research, the number of students included in this study was limited and only focused on one school. This allows the results to be different in other schools with different accreditation and input standards for student admissions. However, the results of this study can be used as evidence that SRL influences students' mathematical communication skills. Furthermore, the impact of SRL on mathematical communication skills is 21%. At the same time, the remaining 79% of students' mathematical communication skills are affected by other factors. So, it requires further research to analyze other factors affecting students' mathematical communication abilities.

CONCLUSION

Online learning causes various changes, one of which is that students should be independent in their learning activities. SRL is believed to be related to improving mathematics abilities, especially mathematical communication. This is clearly shown by the linearity test results, which show a sig deviation from the linearity value of 0.062. From this, we can conclude a linear relationship between SRL and students' mathematical communication skills. A simple linear regression test with a sig level of 0.009 confirms these results. This value is less than 0.05. We can conclude that SRL affects students' mathematical communication skills. The magnitude of the influence of the independent variable (SRL) on the dependent variable (mathematical communication ability) is 21%. At the same time, the remaining 79% of students' mathematical communication skills are influenced by other factors.

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AUTHOR INDEX

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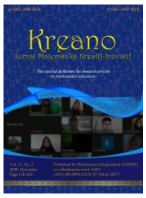

MANUSCRIPT TEMPLATE

A. GENERAL RULES

1. The manuscript is written in Corbel font, size 12, A4 size paper with "Normal" margins. In the manuscript, try to fit the width of the table in half a page (setting two columns), as well as images.
2. In writing a bibliography, please use a reference manager, such as Mendeley or EndNote. Citation and bibliography are written in the APA format which has at least 6 references for each keyword in the title. The minimum number of references used is 25 and 80% of them come from international journals.
3. Journal Kreano does not allow articles written by 1 author. This rule have been applicable since 2018 (Vol. 9).
4. There's no numbering in the manuscript.

B. SPECIFIC RULES

1. Title

Title is written with clear and concise sentences, consisting of no more than 15 words. Titles are written with the type Capitalize Each Word except for conjunctions in-, for-, and the similar phrases. Title is placed in the middle, single space, Corbel font size 14, in bold. For foreign words, the writing is italicized.
Example:

Implementation of the TPS Model with Assisted Probing Prompting Learning CD in Three Dimensions

2. Name, Affiliation, and Corresponding Author

Name of authors are written in two words (maximum), without academic title. Affiliation could be more than one for an author. Corresponding author only one for each manuscript. Corresponding author is an author who submits the manuscript through OJS.

3. Abstrak and Abstract

The abstract begins with a sentence that describes the GAP of your research. Next, the abstract is continued with research objectives, research methods, results, and conclusions. At the end of the abstract, the implications of this research need to be stated. The abstract is written briefly in no more than 150 words for each Indonesian and English. Written in Corbel font size 10pt. Abstract in Bahasa is not necessary for an author from outside of Indonesia. Keywords are written after the abstract using English terms, consisting of 3-5 keywords. If you are author from abroad, ignore writing abstracts in Indonesian. You may leave the identity for blind review.

4. Sub-Title

Section titles are written in capital letters in bold font, for example: **INTRODUCTION, METHOD, RESULT AND DISCUSSION,** and **CONCLUSION**

5. Content

The content is written according to the template. There is no space between paragraphs, but each new paragraph is written 1 cm indented. Writing references or literature, it is enough to write the year without writing the page. Between sections and other sections are given a space of one break. Sub-chapter titles are written in bold italic type. In accordance with instructions no. 4 that the contents of the article consist of:

a. INTRODUCTION

The introduction contains the research background (the story of the phenomena or critical paradigm of the study), theoretical framework, GAP of the study, and ended with a problem statement. The theoretical framework must be justified with the research results. The introduction should be able to explain the contribution of this research in the field.

For theoretical framework references, the editor recommends using primary references, such as Brousseau, Bruner, Vygotsky, Thorndike, etc (Brousseau, 2002b, 2002a; Bruner, 1964; Thorndike, 1914; Vygotsky, 1978). To ensure the novelty of the study, you should compare your research with the research from recent years.

The introduction is as much as 35% of the total length of the text. **3 main things that must be present in the introduction**, namely: (1) **The ideal condition** of learning outcomes in mathematics, or more general form is the dependent variable of a study. Scientific references are needed to strengthen the description of this ideal condition. Usually, government regulations can also be used as references; (2) **The gap** between reality and ideal conditions. In this section, it is better to convey the observation data and researcher's experience in the form of a description; and (3) **Ideas** for minimizing disparities, supplemented by the results of previous related studies.

b. METHOD

This section contains the research methods used. The maximum length of the method is 10% of the entire manuscript if it is **quantitative research** and a maximum of 15% if it is **qualitative research**. The writing method is very dependent on the type of research conducted. In **qualitative research** *(this is highly recommended by the editor),* the writer can describe the focus of the research carried out, whether looking for characteristics of the subject or describing phenomena. In this section, please write down the stages of your research so that the research questions are answered.

In **development research** or **CAR**, the author must write the steps of development and targets at each stage. For example, if your study uses the ADDIE method, you must explain the purpose of each step. If in the Analysis step your purpose is understanding the phenomena, then in the result, you must explain what phenomena happened. Presentation of research stages using a graphic organizer is highly recommended.

The Method is written in paragraphs and divided into 1) participants (and their characteristics such as location, people habit, environment, and culture); 2) instruments; 3) data collection; 4) data analysis. In qualitative research, Editor will ask the author to maintain what we call the trustworthiness of the qualitative data (Lemon & Hayes, 2020; Stahl & King, 2020).

c. RESULT AND DISCUSSION

In the Result, the author will ask to 1) provide a "big picture" perspective for readers to remind them of the importance of your study and 2) provide a critical analysis of your major finding(s).

The writing of research results depends on the type of research. For **Development Research**, write down all the results of each stage of the research, including if there is a flowchart, write in this section. **Quantitative research** results usually produce tables of statistical analysis results. This section is where the table is presented. The results of **qualitative research** are more flexible. Qualitative research writers can write data reduction, analysis results in each section of research, and findings.

For any findings, please compare them with findings in previous similar studies (references are recommended to scientific journals less than 5 years old), so that the findings of this study are clear, whether corroborating previous research or presenting new findings.

Discussion

This section is an elaboration of the findings written in the results section of the study. In qualitative research, this section describes the meaning of the findings of this study. In quantitative research, this section explains the inference from statistics presented in the results section. In CAR research, this section describes the process of research reflection and a summary of actions that illustrate learning success.

References from related research journals must exist, as part of the state of the art of this research. At the end of the discussion, the author should maintain the novelty of the research. By comparing with previous similar research, the author can place the research position.

Implication of Research

Discuss the implications of your research for pertinent stakeholders (e.g., future research for other investigators, practice suggestions for practitioners, or policy considerations for administrators).

In addressing any of these elements, please make sure your discussion remains directly connected with the study you conducted.

Limitation

Discuss the limitations of the study. These limitations can be organized around simple distinctions of the choices you made in your study regarding who, what, where, when, why, and how.

Limitations of your study can be in the form of the number of research subjects that may not be representative, an unfavorable environmental situation, a sample that cannot be controlled properly, or anything that becomes an obstacle in your research. An explanation of this limitation can be a reason that strengthens your conclusion.

d. CLOSSING (CONCLUSSION)

There are several rules of conclusion: 1) Conclusion must be drawn based on research questions and purposes of your study; 2) Conclusion must be a synthesis of key points; 3) Conclusions is written in 1 paragraph.

.

6. *Figure and Table*

Table and images should not be written more than 3 pieces in each manuscript. Tables and figures need to be provided if referred to in the body of the article. If not referred, it is better not to write tables and figures. For general formulas and tables, there is no need to write them, just write the results.

For example, in the SPSS application results table for the normality test, the homogeneity test, and the average difference test, the table does not need to be displayed, just write the results. For tables or figures, as far as possible write in one column as shown in Table 1 and Figure 1.

Table 1. Sample of Table 1

		Levene Statistic	df1	df2	Sig.
Mid - test	Based on Mean	.449	6	211	.845
	Based on Median	.353	6	211	.907

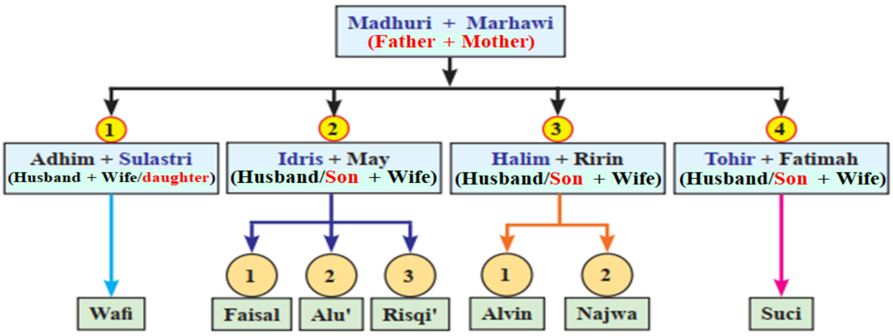

Figure 1. Family Diagram (As'ari, Tohir, Valentino, Imron, & Taufiq, 2017b)

If tables or figures do not allow one column to be written, please use the Text Box, set it to Square in the WRAP TEXT section, and no outline.

7. *Bibliography*

Bibliography is written in APA format, at least 15 references from journals. Each of the keywords in the title, there are 6 references at least.

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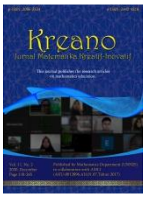

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