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Cover Story: Animated media use cartoon become popular in the mathematics teaching after pandemic.

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Editorial

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Preface

Assalamu 'alaikum wr.wb.

Dear readers of the Jurnal Kreano,

Kreano, Jurnal Matematika Kreatif-Inovatif, Vol. 14 (1), for January to June 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.

After the pandemic, the trend for media development has increased, both in terms of quality and variety of media. Digital media is growing more and more from cartoons, films, to augmented reality.

Research on media development is always interesting. Moreover, the mental condition of students after the pandemic is very different from before. Research on differentiated learning and student attitudes in the classroom is interesting to do in the future. 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, June, 1st 2023
Chief of Editor

Isnarto, Dr.

Kreano

Jurnal Matematika Kreatif-Inovatif

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Students' Understanding of The Equal Sign Based on Their Learning Experience in Arithmetic

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Abstract

The equal sign is an important concept in learning mathematics karena it is used in almost all branches of mathematics, but not many studies in Indonesia have made the equal sign the focus of research. This study aims to explore how students from elementary school to college students understand the equal sign in the context of arithmetic and algebra at school. A qualitative comparative analysis can be used to analyze several cases in complex situations so that it fits the purpose of this study. Participants consisted of 6 elementary school students, 14 junior high school students, 7 high school students and 3 college students in Bandung. The results of the study indicate that the equal sign is still interpreted narrowly as "result" or a sign to put the Answer and has dependence on computational methods in solving problems and drawing conclusions. Thus, it can be concluded that students' understanding of the equal sign is still at the basic level. The results of this study show evidence that the operational meaning of the equal sign that students have when learning arithmetic will not change by itself without the stimulus provided by the teacher, and even tends to cause obstacles when students learn equations in algebra.

Keywords: *algebra; arithmetic; the equal sign; qualitative comparative analysis*

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Abstrak

Tanda sama dengan merupakan konsep penting dalam pembelajaran matematika karena digunakan pada hampir seluruh cabang matematika, namun belum banyak penelitian di Indonesia yang menjadikan tanda sama dengan sebagai fokus penelitian. Penelitian ini bertujuan untuk mengeksplorasi bagaimana para siswa dari mulai sekolah dasar hingga mahasiswa memahami tanda sama dengan dalam konteks aritmatika dan aljabar di sekolah. A qualitative comparative analysis dapat digunakan untuk menganalisis beberapa kasus dalam situasi yang kompleks sehingga sesuai dengan tujuan penelitian ini. Partisipan terdiri dari 6 siswa SD, 14 siswa SMP, 7 siswa SMA dan 3 Mahasiswa di Bandung. Hasil penelitian menunjukkan bahwa tanda sama dengan masih dimaknai secara sempit yaitu sebagai "menghasilkan" atau tanda untuk meletakkan jawaban, serta memiliki kebergantungan terhadap metode komputasi dalam menyelesaikan masalah dan mengambil kesimpulan. Dengan demikian, dapat disimpulkan bahwa pemahaman siswa tentang tanda sama dengan masih berada di tingkat dasar. Hasil penelitian ini menunjukkan bukti bahwa makna operasional dari tanda sama dengan yang dimiliki siswa pada saat belajar aritmatika tidak akan berubah dengan sendirinya tanpa adanya stimulus yang diberikan oleh guru, bahkan cenderung menimbulkan hambatan saat siswa belajar persamaan pada aljabar.

INTRODUCTION

Students' understanding of the equal sign, which is still in the operational category, namely as a sign to carry out a series of computational processes, is one of the main stumbling blocks for students to succeed in algebra. This is because almost all manipulations in algebraic equations require the understanding that the equal sign is a symbol denoting a relational equivalence of both sides of the equal sign rather than simply the result of calculations. Many thoughts and studies in various countries have explored students' understanding of the equal sign, starting from the elementary school level (such as Vermeulen & Meyer, 2017), high school (such as Kindrat & Osana, 2018) to tertiary institutions (Baiduri, 2015) stating that the meaning 'same' is a complex and difficult notion to grasp. The researchers observed that students still tend to regard the equal sign in arithmetic sentences as an operational symbol, namely the equal sign is interpreted because of calculations or an answer to a problem, so they tend to read and perform calculations on algebraic equations from left to right.

Preliminary studies that have been conducted on 2 elementary school students, 3 seventh grade junior high school students, and 1 student show conditions in the field where there is a similar tendency, namely giving responses based on a result-oriented process so that they have a "must to calculate" which is categorized as an operational view of the equal sign. When students encounter expressions like 5 + n, for example, most students tend to write 5n as 'answer'. In addition, elementary school students also often react negatively when sentence numbers do not match the conception they have so far, such as in sentences of the form c = a + b then change them to a + b = c. In sentences of the form a + b = _____+ d, students tend to write down the sum of a + b in the ___ section and when students are given math sentences 3 + 5 = _____+1, students tend to fill in 8 in the ____ section. This is in accordance with Alibali's (2007) statement, namely that although the equal sign is a very important concept for understanding mathematics at all levels of school mathematics, the meaning of 'same' is a complex and difficult idea for most students to understand.

The meaning of the equal sign (=) in mathematics expresses an identity relationship that is, equal (is equal to / is the same as) or identical (is identical to) where all refer to the specific relationship of the equivalence relation. That is, equality has a different meaning from equivalence because there are other equivalent relations which do not refer to the same relationship. Even though there are differences, equivalency and identity do share some of the same properties, namely identity (equality) is a certain equality relationship in the sense of being reflective, transitive, and symmetrical (Mirin, 2019). The equal sign is very important to be interpreted as a relational sign that tends to be non-computational in order to understand rules in an algebraic context, because in the process there are many cognitive demands that must be met by students to operate on algebraic symbols, for example students need to accept that a sign of arithmetic operations such as '+' , '-' and '=' have multiple meanings. It is intended that students can understand the meaning of different symbols according to the context, choose one that is appropriate to the situation, and recognize that symbols represent results and processes.

A formal understanding of mathematical equivalence involves students' understanding of the equal sign as a relational symbol such as encoding and identifying two sides of an equation, the equal sign not only as a process but also as a mathematical object that can be manipulated or acted on, numbers and expressions can be represented in a variety of different ways. interchangeably claimed by some researchers such as (Baiduri, 2015; Knuth et al., 2006; McNeil, et al, 2017) is important for students because it becomes a basic concept in mathematics which makes it easier for them to acquire new mathematical information, facilitates conceptual understanding of arithmetic, improve math achievement, and promote algebra readiness such as solving algebraic equations in high school. Baiduri (2015) reports that students need a relational perspective in learning to solve algebraic equations using operations on both sides, for example, $5x - 5 = 2x + 1$ and understand that the transformations made in the process of solving equations must maintain equality.

The National Council of Mathematics Teachers Principles and Standards for School Mathematics (NCTM) in 2000 recommended that algebraic thinking be emphasized not only at the secondary school level but also at the elementary level. This is an appeal to teachers in elementary schools to cultivate students' ability to find patterns, generalizations, and other skills to develop basic knowledge in children that will support algebra learning in the next class. The equal sign is a very important symbol for students in primary and secondary schools to learn because it is the basis for understanding equations where equations are the essence of understanding algebra. An understanding of equality is inseparable from the concept of an equal sign so that the concept of an equal sign and the concept of equality cannot be separated (Baiduri, 2015). Students' understanding of the equal sign in an equation is the basis for supporting the transition from arithmetic to algebra (Leavy, Hourigan, & McMahon, 2013). The equal sign can cause many difficulties for students in understanding algebra if it is not understood correctly (Banerjee, 2011). Therefore, students' understanding of the equal sign is an important foundation for their success in learning algebra (Stephens, et al., 2013).

Some of the studies previously mentioned (such as Baiduri, 2015; Kindrat & Osana, 2018; Knuth et al., 2006; McNeil, et al, 2017; Vermeulen & Meyer; 2017) have not used a qualitative comparative analysis methodology in conducting an analysis for seek and find similarities and differences in phenomena. This study aims to explore various information about learning experiences and the meaning of the equal sign resulting from these learning experiences. The various kinds of experiences found are then sought for similarities and differences in the meaning of the equal sign which are then used to find learning experiences that are often experienced but do not support a strong understanding of the equal sign as well as learning experiences that can support a strong understanding of the equal sign so that students can relate meaning to the procedures normally used to solve algebraic equations.

METHOD

This study uses a qualitative comparative analysis methodology, a case-based approach that is regularly used to investigate situations in specific contexts and settings. A qualitative approach was chosen because this study aims to investigate things that exist in natural settings and try to interpret these phenomena. The comparative perspective is considered the most suitable for the purpose of this research because this research was conducted on three groups of students with different grades. The reliability techniques used in this study include field notes, audio recorders for accuracy, and coding techniques. The themes and codes were derived from qualitative data which were informed by the theoretical framework that supported the research and the literature review. The identified validation techniques commonly used in this study included triangulation of data sources to corroborate evidence, and member checks were performed to determine the credibility of findings and interpretations.

The selection of the sample used in this study used an incidental sampling technique which involved selecting individuals who happened to be available and accessible at that time. Researchers take samples at random (whenever and wherever they find) as long as they meet the requirements as samples from the desired population, so that bias can be minimized. The population in this study is homogeneous, namely students who have learned about the equal sign in arithmetic and/or school algebra. In this case, the researcher does not attempt to generalize about the wider population but uncovers existing phenomena. There were 30 participants in this study. All participants are elementary school students aged 12 to graduate students aged 45, have learned about the equal sign at school arithmetic / algebra, and are willing to voluntarily become participants. The respondents of this study consisted of 30% men and 70% women. There are 20% elementary students, 70% junior and senior high school students, 10% university students in Bandung, Indonesia. All participants in this study were individuals who were different from participants in the preliminary study.

The problem of trustworthiness in this study is improved through checklists in each stage of the research, namely from the preparation stage, the organizational stage, to the reporting stage as described by Elo, et.al., (2014). The stages of this research are shown in Figure 1.

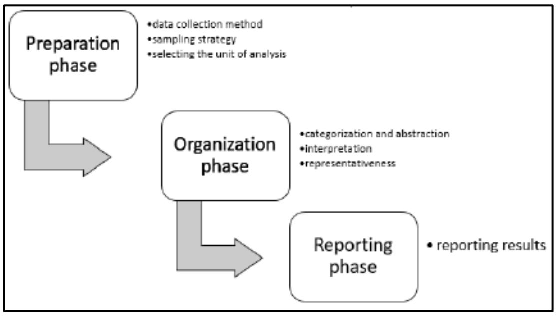

Figure 1. Research Stages

Checking the validity of the data in this study was carried out through credibility, transferability, dependability, and confirmability tests. The credibility test is carried out by extending observations,

Table 1. Stages of Relational Thinking about the Equal sign

Rigid operational	Students are asked to solve problems in the standard "a + b = c" format
Flexible operational	Students are asked to solve equations in several non-standard formats for example "c = a + b"
Relational with computational support	Students are asked to solve equations with operations on both sides, for example "a + b + c = a + _____"
Relational without computational support or fully relational	The relational view dominates, and students demonstrate an understanding for the nature of equality

persistence of observations, and triangulation to ensure that the data obtained previously and those obtained from the results of extended observations do not experience significant changes or differences. The extension of the observation was carried out by means of repeated interviews; persistence in making observations by means of document analysis, reading various references, and comparing with the results of previous studies; while triangulation was carried out using several different methods in collecting data in the field, namely written tests, interviews, and document analysis in the form of student notebooks and textbooks used to study the equal sign at school.

The transferability of this research is enhanced through detailed, clear, systematic, and reliable descriptions. Dependability testing is carried out by always actively discussing research progress and showing every "trace" of activity in the field with the supervisor. Meanwhile, confirmability is done by associating research results with the entire research process that has been carried out. The confirmability test is carried out simultaneously with the dependability test.

Before being asked for personal consent by the researcher, students had been given an understanding that they would be given the task of answering several questions about the equal sign, answers had to be honest according to their personal thoughts and any answers they gave were not related to their school grades, and these answers would be documented in a research report with guaranteed anonymity.

The researcher assured the participants that the data collected would be treated confidentially and that no punitive action would be taken against them if they decided to withdraw. All participants have filled out written statements willing to participate in this research voluntarily and without coercion from any party. Students who are willing to complete the task are participants of this study. The instrument used in this study was a task-based interview referring to the four stages of relational thinking proposed by Matthews, et.al., (2010) to increase difficulty. All questions in tests and interviews use Indonesian. The tasks given consist of two types, namely open number sentence questions for tasks 1, 2 and 3; as well as true or false number sentence questions for task 4.

There are four main types of questions used in several arithmetic and symbolic formats, namely: type 1 (arithmetic identity) which aims to interpret the equal sign and provide an answer; type 2 (algebraic equations) aims to determine solutions to algebraic equations; type 3 (mathematical statement) to interpret the equal sign by stating whether the number sentence is true or false and to write the mathematical sentence into a regular sentence; and type 4 (symbol interpretation) to interpret the meaning of the symbols "=,_____, , and n". After the respondent completes the written task then proceed with the interview process. Investigations

Table 2. Student Performance on All Tasks

Level	Tasks (T: True, F: False)							
	1		2		3		4	
	T (%)	F (%)	T (%)	F (%)	T (%)	F (%)	T (%)	F (%)
Elementary School (SD)	17	83	0	100	0	100	0	100
Junior High School (SMP & SMA)	79	21	50	50	54	46	53	47
College	90	10	86	14	85	15	82	18

and follow-up questions were added as needed to encourage elaboration and clarification of responses. Specific questions were added as the interview process progressed according to the responses provided by the informants.

After they filled out the written assignment, the researcher then conducted an interview session with a duration of between 10 and 15 minutes. Each question asked aims to confirm their answers, the difficulties, or obstacles they may experience, what experiences, why and how so that they understand the meaning of the equal sign, contextual questions, and additional questions according to the responses given. The documentation included students' written answers along with every stroke they wrote on the answer sheets provided, audio recordings during the interview process, and analysis of textbooks used at school.

Data collected from answers to written assignments were analyzed using the following categories: (a) correct and incorrect responses; and (b) operational and non-operational arguments. Incorrect responses are given a value of zero (0) and correct responses are given a value of one (1). Both incorrect and correct responses related to understanding of the equal sign were followed up during the interview. Responses were coded as operational if a student expressed the general idea that the equal sign means 'add a number' or 'answer', and 'signal to compute' (Alibali, et al., 2007) and coded as non-operational if with no calculation or with calculation only to justify written relational responses (Kindat & Osana, 2018).

The findings from this study are presented and discussed according to the theme of the research question, namely: student performance, strategies used, and learning experiences applied in completing written tasks.

RESULTS AND DISCUSSION

Student Performance

The performance of all respondents in completing the task is presented in Table 2 below. The number of students who have correct (B) and incorrect (S) answers is written as a percentage (%). Table 2 shows that respondents performed better on tasks that involved calculations than those that did not involve calculations. This became one of the important results of this study, namely that respondents, both several students or a number of adults, responded to open number sentences and true/false number sentences based on a result-oriented process so that they have a 'necessity to calculate' which often encourages the view operational of the equal sign. Students are more likely not to regard the equal sign as a symbol indicating a relationship but as 'finding a result or doing something', 'a sign for calculating', and 'an operation symbol or symbol-syntax indicator used before an answer' where these findings are in harmony with several studies such as Barlow & Harmon (2012); Kiziltoprak & Kose (2017); Machaba (2017); Matthews, et.al., (2010); Stephens et al., (2013). The operational view of the equal sign suggests limited knowledge about the meaning of the equal sign which can hinder students' performance in algebra (Matthews, et.al., 2010). The operational view of the same sign is mostly claimed by some researchers as a 'side effect' of students' experiences with symbols in elementary school mathematics (Knuth, et al., 2008; McNeil and Alibali, 2005; Vermeulen & Meyer, 2017).

In task 1, even though it was only oriented towards arithmetic operations in a standard format, the performance of all students was not optimal because they were used to the right side of the equal sign showing results. Students tend to interpret expressions in the same way as reading numbers, namely sequentially from left to right. For example, in the first question, namely filling ____ in 8- ______ = 10 with a value that is considered correct, students who fill in 2 as an answer think that the subtraction sign is the difference of two numbers without paying attention to the position of the equal sign or answering 6 voluntarily reformulates the syntax such as reading 19 = 6 + 25 as '6 plus 25 equals 19'.

Task 2 has a flexible operating difficulty level where students are asked to solve equations in several non-standard formats. The types of questions posed in task 2 allow the respondent to induce equivalent additive pairs based on transitive relationships. This ability is a fundamental arithmetic skill that allows writing number sentences with mathematical symbols, understanding the basic features of operations and conceptualizing numbers in various forms (Koziltoprak & Kose, 2017). Question 2.2, namely filling in the box at $4 \times 3 = 7 + \square$ with a value that is considered correct, is the question that has the worst performance in task 2. The four respondents who answered 14 saw an equal sign as a kind of command to complete the calculation '4+3+7' and make answers in the box without paying attention to the operation sign and the equal sign in the given mathematical sentence. Meanwhile, the other three respondents add up 4×3=12 and then add 7 for a result of 19. They assume that 'equivalent' is something to indicate that it is necessary to add an answer (Darr, 2003). It seems that the equal sign is often presented in contexts that support operational interpretations, such as problem structure 'operations equal answers' (e.g., 38 + 27 = ?), 'find the total' or 'put the answer'. Although the 'operational' view may be sufficient when solving typical elementary school arithmetic problems, it can become problematic when students encounter more complex equations in later grades e.g., 3x + 5 = 11.2x - 3 = 4x + 5 (McNeil, et al., 2017). High school students who are advanced in arithmetic don't seem to have a sophisticated interpretation of the equal sign either. Their performance decreases as the difficulty level of the questions increases.

Task 3 involves more than two operations in one sentence which is a special problem that can only be solved if students have a broad understanding of the equal sign (Molina & Ambrose, 2006). There are still many high school students who experience parsing obstacles as reported by (Gunnarson, Sonnerhed & Hernell, 2015) to be the cause of these errors. Students have performed fairly well in all task 4 questions except in the question of determining true or false of 4.3, namely 8 + (3 × 8) = (5 × 8)- 8 and 4.4, namely 42:16 = 84:32. Question 4.3 generally students stated "false" because they saw that the math sentence has a different form on the left and right sides of the equal sign where they believed that 8 + (3 × 8) would not have the same result as (5 × 8)- 8. In question 4.4, all students believe that the quotient of the left and right sides of the equal sign will not be the same because the right side has a larger number than the left side so it is certain that the right side will have a greater quotient than the left side of the equal sign.

Student Strategies in Completing Tasks

Task 1

Task 1 involved students with four standard equations in an arithmetic context to assess students' knowledge of the equal sign with a rigid operational level of difficulty i.e., only succeeding on equations in the standard format 'a + b = c' and thinking of an equal sign operationally to test whether the respondent understood that variables represent specific and constant numerical values (Matthews, et al., 2010). Even though task 1 was at the easiest level of difficulty, there were around 38% of respondents who had difficulty answering each question item correctly. All respondents used a computational strategy in answering questions. They see the equal sign as a kind of command to complete calculations and create answers. So that many students, even adults, end up being 'stuck' in calculations that don't make sense. When traced in the interview session, they only focused on "doing something to get results" without paying attention to the equal sign as a "relation" and the operations used in the equation. This shows evidence that the concept of equal sign gets less attention in the teaching and learning process in the early grades. This kind of situation is a barrier that prevents individuals from internalizing the properties and meaning of arithmetic operations, from establishing relationships and even from generating deep mathematical thinking (Kiziltoprak & Kose, 2017).

Task 2

The questions in task 2 have a flexible operational difficulty level where students are asked to solve equations in several non-standard formats such as 'a=b+c'. This ability is a fundamental arithmetic skill that allows writing number sentences with mathematical symbols, understanding the basic features of operations and conceptualizing numbers in various forms (Koziltoprak & Kose, 2017). Respondents involved in this study admitted that they almost always saw operations in traditional arithmetic practices, namely to the left of the equal sign and 'answer' to the right (McNeil, et al., 2017). From Table 2 it is known that the respondents did not perform better in task 2 compared to task 1. This situation can be attributed to the fact that students learn arithmetic to be result oriented and that they focus on computation rather than the relationship between numbers and operations.

Task 3

The questions in Task 3 are designed to investigate students' ability to solve equations with operations on both sides. Through computing support, it is hoped that it will be able to bring up a relational view with an operational view. These problems are designed to test students' knowledge of the properties of arithmetic equivalence, for example the distributive property, which has been cited as the rationale underlying formal transformational algebra (Matthews, et al., 2010). The square and triangle symbols are given to ensure students do not have a dependency on certain symbols to indicate unknown. This is expected to be a good introduction to students' understanding of variables. According to the nomological network of changes resistance accounts defined by McNeil, et al, (2017) that solving equations, encoding equations, and defining the equal sign are three different, but theoretically related, constructs involved in children's understanding of mathematical equality.

Task 4

Task 4 provides eight statements varying from arithmetic to algebra and in the form of true/false number sentences. Statements are given in the form of true and false number sentences that can be used to help develop conceptions about the equal sign (Kindrat & Osana, 2018). Respondents were asked to indicate whether the sentence was true or false by circling the symbols '(√) or (B)' for statements they considered correct and '(×) or (S)' for statements they considered incorrect on the test paper. Respondents were then asked to provide reasons for the answers given as well as written justifications for their responses in the blank space provided for the questions.

All respondents (except elementary school students) used computational-relational arguments, namely using calculations to justify their responses. They understand that both sides of the equal sign have the same value and confirm it with calculations (Kindrat & Osana, 2018; Stephens, et al., 2013). This idea was confirmed during the interview. They still have a very high dependence on computing to answer every question. Even adults who are very proficient in algebra respond 'true' to each question with the argument 'the equal sign guarantees that the left and right sides must have the same value' but the strategy used is still computational to ensure that the left side of the sign equals has the same value as the right hand side. Even though they are expected to be able to provide arguments for numerical relationships, for example in a mathematical sentence 10 + 16 = 15 + 11 is true 'because 11 is 1 greater than 10 and so are 16 and 15'.

Learning Experience

Completing arithmetic arithmetic operations in the format a+b=c is the most common learning experience throughout elementary school mathematics learning. So that in general, respondents do not see the equal sign as a 'relationship' but as an operational sign to perform calculations from left to right where the numbers to the right of the equal sign are the result of calculations from a series of arithmetic operations to the left of the equal sign. The equal sign and blank answers in arithmetic problems are usually presented regularly at the end of the problem (e.g., 4 + 7 = ...; 4 - 3 + 6 = ...). However, many higher-level problems don't fit a pattern like "2 × ... + 6 = 20" doesn't have a blank answer to the right of the equal sign. This kind of learning experience has also been reported by several researchers (e.g., Fuchs, L.S. et al., (2014); Kiziltoprak & Kose (2017)).

Understanding of the equal sign as "complete answer" is so strong that Darr (2003) also found that out of 300 students more than half wrote 9 or 12 in the box in equation 4 + 5 = ____+3 as the answer in his study. Likewise with McNeil, et al. (2017) found that when elementary school students from grades one to six were asked sentences such as 8 + 4 = ____ + 5, less than 10% of them were able to give the correct answer. Molina & Ambrose (2008) reported that elementary school students tend to consider the equal sign in arithmetic sentences as operational symbols and react negatively when arithmetic sentences do not match the conception they have so far, such as in sentences of the form c = a + b then change them to a + b = c.

Learning experiences such as completing arithmetic operations in the format "a+b=c" when taught in a very procedural way with little or no reference to the relational concept of the equal sign can form a student's concept image including: the equal sign as "result" " so it can lead to misconceptions about closure types, such as writing ____ with 1 in the equation

____+3=4+5; the equal sign as a marker to put the answer so that the format is like a=a; a=b+c or a+b=⋯+d is hard to understand; the equal sign as the answer marker so that it will tend to fill in 2 at 8-____=10 where the number 10 is "answer"; and an equal sign as a marker to put the answer filling in _____ with 10 at 4 + 6 = _____ + 5.

There are three approaches that apply to introducing a more sophisticated the equal sign to children to provide a more meaningful arithmetic learning experience according to McNeil, et al (2017), namely: 1) focusing on explicit conceptual instructions; 2) focuses on practice with basic arithmetic facts; and 3) focusing on the role of existing knowledge in children's difficulties. The first approach aims to help children examine and reflect on the relationships between the fundamental properties of operations and numbers and express them as generalizations. The second approach aims to increase proficiency with basic facts, higher order thinking and problem solving. Whereas the third approach aims to build a better understanding of mathematical equivalence through non-traditional problem formats, activating students' relational thinking and understanding of equivalence through relational words such as "is the number equal to" instead of using the "=" symbol used for represent equivalences, as well as organize arithmetic problems into exercise sets that allow students to induce equivalent additive pairs based on transitive relationships (eg if 3 + 4 = 7 and 5 + 2 = 7, then 3 + 4 = 5 + 2).

Implications

It is hoped that the results of this study can provide some information to mathematics curriculum developers, mathematics book authors and mathematics educators so that they can provide more opportunities for elementary, secondary and university students to develop concepts correctly about the equal sign. Instead of waiting to introduce the concept during the middle school years, teachers should help students in elementary schools to recognize the equal sign as a symbol representing equality relationships.

Limitations

This research has limitations, including the small number of respondents in one of the big cities in Indonesia, which also limits the variety of responses, and the study has not been conducted longitudinally to see whether the students' understanding that has been found will change or last from time to time. Nonetheless, the respondents involved came from various school levels. So, the results can be used as evidence that students' understanding of the equal sign will not change by itself along with the high school level.

CONCLUSION

Based on the findings obtained in this study indicate that many students at all grade levels have not developed an adequate understanding of the meaning of the equal sign. Students' understanding of the equal sign is evidently not a type of problem that can be considered trivial. Adequate understanding of students about the equal sign does not happen instantly because the equal sign has been introduced to students since they were in elementary school when they studied mathematics at school and they have little time to learn this symbol in the next class. Students' misunderstanding about the equal sign still occurs in higher education. The findings of this study support this claim.

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Fun Learning Method in Effecting the Students' Interest in Learning Mathematics

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Abstract

This study is based on the low interest of students in learning mathematics. The phenomenon was indicated by the activities of students who are often outside the classroom during mathematics learning, the students do not ask when there is confusing material, the students do not complete the task given, and some students are sleepy during the learning process. These conditions indicated a low level of learning interest. At the same time, interest is crucial in learning mathematics because it affects students' learning achievement. Regarding the condition, the teacher's role is to increase the student's learning interest by applying appropriate methods. One of the learning methods that is assumed to be able to attract students' learning interest is the fun learning method. The fun learning method in this study was applied through classroom action research with two learning cycles. This study aims to know the effect of fun learning methods on students' interest in mathematics. This study was conducted at VII.7 grade of SMP Negeri 1 Pinrang, South Sulawesi. The research instrument used was a questionnaire and an observation sheet. The data was collected through a questionnaire and observation, then the data collected was analysed using descriptive statistics. Indicators of increased interest obtained from questionnaires show an increase in the average percentage of student interest in learning from the moderate category of 2.88 to the good category of 4.08, which meets the average indicator of students' interest in learning mathematics of 3.50 in the good category. In contrast, other indicators are shown through the results of observations of student activity, namely an increase in the percentage of student activity from 44.2% to 75.4%, which met the success indicator of 75%. The result showed that the fun learning method could increase the student's interest in mathematics.

Keywords: *Fun Learning; Interest; Mathematics; Method*

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Abstrak

Penelitian ini berawal dari rendahnya minat siswa belajar matematika. Gejala ditunjukkan adanya aktivitas siswa yang sering berada di luar kelas pada saat pembelajaran matematika berlangsung, siswa tidak bertanya ketika ada hal yang tidak diketahui pada materi yang diajarkan guru, siswa tidak mengerjakan soal-soal yang diberikan, serta beberapa siswa mengantuk saat pembelajaran matematika berlangsung. Kondisi ini mengindikasikan minat belajar yang rendah. Padahal peran minat sangat penting dalam pembelajaran matematika, karena merupakan faktor yang berpengaruh terhadap hasil belajar siswa. Dengan kondisi tersebut, maka dibutuhkan peran guru dalam meningkatkan minat belajar siswa dengan menerapkan metode yang tepat. Salah satu metode pembelajaran yang diasumsikan dapat menarik minat belajar siswa adalah metode fun learning. Metode fun learning dalam penelitian ini diterapkan melalui penelitian Tindakan kelas sebanyak dua siklus pembelajaran. Penelitian ini bertujuan untuk mengetahui pengaruh penerapan metode fun learning yang dapat meningkatkan minat belajar matematika siswa. Penelitian dilakukan dikelas VII7 SMP Negeri 1 Kabupaten Pinrang, Sulawesi Selatan. Instrumen penelitian yang digunakan berupa lembar angket dan lembar observasi. Data dikumpulkan melalui teknik angket dan teknik observasi, selanjutnya dianalisis secara statistic deskriptif. Indikator peningkatan minat yang diperoleh dari angket menunjukkan meningkatnya persentase rata-rata minat belajar siswa dari kategori cukup sebesar 2.88 menjadi kategori baik sebesar 4.08, memenuhi indikator rata-rata minat belajar matematika siswa sebesar 3,50 berada pada kategori baik, sedangkan indikator lain ditunjukkan melalui hasil observasi aktivitas siswa, yaitu meningkatnya persentase aktivitas siswa sebesar 44.2% menjadi 75.4%, memenuhi indikator keberhasilan sebesar 75%. Hasil penelitian menunjukkan bahwa metode Fun learning dapat meningkatkan minat siswa belajar matematika.

INTRODUCTION

Mathematics is a subject that has a big role in the education world because mathematics is applied at all education levels. Mathematics learning in schools is not only intended to achieve the objectives of material mathematics education that equip students to master mathematics and apply it in daily life. However, mathematics learning is also intended to achieve the goals of formal mathematics education that organize the students' reasoning and shape their personalities (Mustafa, 2021). Mathematics as one of the subjects in the school should be managed to be interesting and fun so the students are interested to learn it and then succeed in achieving the objective of mathematics learning.

Mathematics learning must be designed to make the students enjoy it to encourage their interest in participating in the learning process. Interest is a feeling that occurs because it relates to something. Interest can be learned and affect the next learning activity, influencing the acceptance of new interests. So, interest in something results from learning and supports the next learning activity. A strong interest in learning mathematics will make the students more successful in mathematics learning (Kamid et al., 2021). Interest indirectly affects students because their interests influence the standard of attraction to someone. Interest in learning is a significant factor that determines the learning activities of learners (Burke, 1995). Triarisanti et al. (2019) revealed that high interest in learning would affect the process of successful teaching and learning activities. In learning mathematics, students relate to learning activities. Interest in learning will create immediate attention, facilitate concentration, prevent distraction, strengthen attachment to learning material, and reduce the boredom of learning.

The preliminary information about students' interest in learning mathematics was obtained through observation. The observation was conducted at Junior High School 1 Pinrang, especially in class VII, related to how students' activities follow the learning process, the learning methods used by teachers, and their mathematics learning achievement. The observation result found that there were activities of students who are often outside the classroom during mathematics learning, the students do not ask when there is confusing material, the students do not complete the task given, and some are sleepy during the learning process. As a strength, interviews were conducted with mathematics teachers, and information was obtained that student activities that tend to be passive following the learning process have impacted low mathematics learning achievement, an average of 65, which is below the minimum completeness criteria set 75.

One of the factors of the low students' learning achievement due to the low students' interest in learning mathematics. With the learning methods used by teachers being teacher-centered, they need to involve students in the learning process. Based on the condition, the teacher's role is needed to increase the student's learning interest by applying the appropriate method. The method applied is expected to create enjoyable situations so that students do not feel bored and convenient while learning mathematics so that the student's learning interest can increase, and ultimately affect students' learning achievement. One learning method that is expected to create a fun situation for students to not feel bored during the learning and easy to learn mathematics and can increase students' interest in learning mathematics is the Fun Learning method.

The fun learning method is interesting. According to Berk (2006), an interesting learning process uses a fun learning process using fun methods with patterns and directions of application exemplified by the teacher in the delivery of learning materials so that students can understand the material presented, which makes the learning process does not dull. Fun Learning is a holistic approach to education to nurture the passion for learning and continuous development throughout life. According to Mauli et al. (2021), the Fun Learning approach encourages collaborative learning through play and exploration. In other words, fun learning is the pattern of a good relationship between teachers and learners in the learning process.

The fun learning method has three steps: 1) Finding. In this step, the students are asked to find out the concept of the material by themselves. 2) Uttering, in this step, the students reveal and discuss the result of the steps with the teacher and their classmates. The teacher has an important role as the examiner of the students finding and gives corrections if there is a wrong student's concept. 3) Nailing, in this step, the concept has been applied and reflected with the real condition, so the students understand the material. Nailing activity means that this activity is conducted to "advance or stick" things that students have learned. Regarding a sequence of learning activities in the classroom, reflection is expected, which can effectively aid students in controlling their thinking processes and feeling. Because often in schools dominated and controlled by adults, students rarely make their own decisions about their learning process.

Specifically, in the research of fun learning methods developed in learning mathematics in 5 stages, namely (a) Conditioning Stages: The atmosphere and environment of teaching and learning activities can be conditioned by forming groups or arranging attractive benches, (b) Exploration Stages: It creates or brings about a common experience that all students can understand, (c) Material Presentation Stage: The teacher delivers the material learned using media, interesting pictures, and ice-breaking games, (d) Performance Stage: The teacher gives a chance to the student to show that they understand the material, (e) The Last Stage: The teacher gives directions to review the learning again and celebrate every achievement the students showed during the learning process.

Fun learning is very necessary for every learning process. It helps students get a meaningful learning process and gives satisfaction because it is the main factor determining. The problem in this research is whether the fun learning method can increase interest in mathematics learning. because meaningful and fun activities can help students learn math better. One way to create fun learning activities is to provide entertainment while learning.

METHOD

This research is classroom action research conducted in two cycles. The subjects in this study were students of class VII7 Junior High School 1 Pinrang, South Sulawesi. The stage of cycles is explained in the Figure 1.

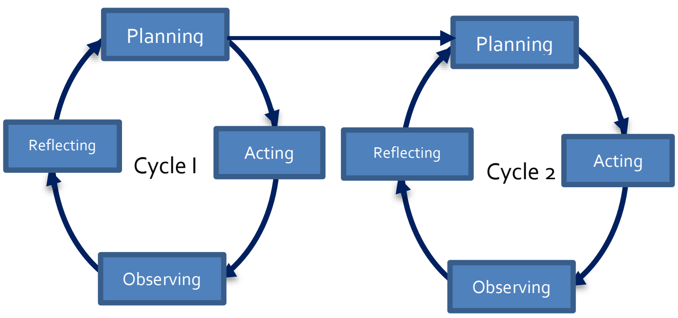

Figure 1. The cycle of classroom action research

Planning. At this stage, the researcher explained the preparations for the implementation of the research, which included preparing lesson plans, compiling instruments such as observation sheets of activities, and interest questionnaire sheets as a measuring instrument to determine students' interest in learning mathematics at the end of the cycle.

Implementing (action). The activity undertaken at this stage was implementing learning according to the planning that had been prepared. The learning mathematics process conducted in the classroom applied a fun learning method. It is observed objectively by the observer based on the learning situation. The questionnaire sheet was distributed at the end of the lesson after the entire learning process was completed. The observation sheet and questionnaire used contained several statements prepared based on the interest indicators determined in this study, including (1) attention, (2) interest, (3) involvement, (4) enthusiasm, and (5) pleasure. Technically, the implementation of learning at the action stage is described in the following table.

Table 1. The Stages of Applying the Fun Learning Method on Learning Mathematics

The Stages	Learning Activity
Conditioning: Condition the learning atmosphere and environment, such as forming groups or arranging attractive seats.	Arranging the learning environment according to students' preferences and comfort, motivating students, and talking intimately and humorously.
Exploration: Generating everyday experiences that all students can be related to.	Providing apperceptions about previous learning and relating with the topic to be learned, providing contextual problems, and exploring concepts.
Material Presentation: Present the material learned using media with exciting pictures and ice-breaking games.	Explain the material to be learned, provide ice-breaking, and then distribute the student worksheet to each group.
Demonstration:	Monitoring/guiding students working on the questions given.

The Stages	Learning Activity
Allowing students to show that they understand the material being taught.	
The Last Stage: Giving directions to repeat the entire lesson and celebrating any achievements that students have shown during the learning process.	Providing good models and appreciation to students who complete mathematics tasks.

The stages are applied in each cycle. However, based on reflection, particular emphasis will be given to specific stages that are improved in the next cycle.

Observation. learning process. The researcher observed students' learning activities while delivering learning material. Next, the researcher asked for help from a colleague as a collaborator to observe the learning process. The collaborator observes the learning process based on the instrument compiled by the researcher. The researcher will use the result of observation from the collaborator as a reflection for the next learning improvement.

Reflection. Reflection is conducted when the collaborator (the observer) has finished the observation of the learning process conducted by the researcher. This stage is the core of classroom action research when the collaborator reveals which part is running well or not when the researcher manages the learning process. The result of reflection is used as a consideration in planning the next cycle.

Obtaining the data needed in this study, the instrument of research used to collect data is the questionnaire and observation sheets. Next, the collected data were analyzed using descriptive statistics. The criteria of interest in this research are explained in Table 2.

Table 2. The Criteria of Learning Interest

Score	Criteria
$4.50 \leq x \leq 5.00$	Very Good
$3.50 \leq x < 4.49$	Good
$2.50 \leq x < 3.49$	Good Enough
$1.50 \leq x < 2.49$	Fair
$1.00 \leq x < 1.49$	Poor

The instrument used in this research is a questionnaire. A questionnaire is used to gain data about mathematics learning interests. The questionnaire used in this research is closed, whereas it has provided statements arranged by the researcher. The questionnaire consisted of five indicators that are stated in the Table 3.

Table 3. Indicator of Interest and Statements Number of Questionnaire

Indicator	Statements	
	Positive	Negative
Attention	14	2, 7, 16
Interest	12, 17	4, 11
Involvement	8, 10, 15	3, 9
Enthusiasm	5, 18, 19	13
Happiness	6, 20	1

The questionnaire of learning interest using the Likert scale is explained in the Table 4.

Table 4. The scoring of the questionnaire for learning interest

Positive Statement	Score	Negative Statement	Score
Strongly Agree	5	Strongly Agree	1
Agree	4	Agree	2
Indecisive	3	Indecisive	3
Disagree	2	Disagree	4
Strongly Disagree	1	Strongly Disagree	5

The worksheet and the observation sheet are also used in this research. A learning achievement sheet measures students' success with the mathematical learning material. Moreover, the worksheet is distributed at the end of every cycle. The observation sheet used in this research aims to gain data about students' activities during the learning process and teacher competence in managing the learning process using the Fun Learning method. Before it is implemented, all research instruments have been validated. In this study, the student's interest in learning mathematics increases if the learning activity shows an increase in the number of active students from cycle 1 to the next cycle with the criteria of 75% of the total students in the class, the average student interest in learning mathematics 3.50 is in a good category.

RESULTS AND DISCUSSION

Results

This study was conducted in the VII_7 grade at Junior High School 1 Pinrang South Sulawesi through the fun learning method. The learning process was taken in eight meetings, with details of six meetings for learning and two meetings for giving questionnaires related to mathematics learning interests.

The Data Presentation of Cycle 1

Planning. The research activities began with the planning stage, where the researcher developed a lesson plan using the fun learning method. The lesson was designed following the stages of the fun learning method set out in this study. The researcher also ensured that the validated research instruments were ready for use. In addition, the researcher coordinated with the team involved, the observer, and monitored the readiness of students who would participate in the learning process.

Implementing (action). After compiling the planning, the next stage was implementing stage. At this stage, the researcher implemented the activities planned. The learning was conducted following the stages of the fun learning method. The conditioning and the exploration stage are conducted in the introductory activity. Next, the material was presented, and the demonstration was conducted in the core activity. Furthermore, the direction was delivered in the closing activity. Cycle I was conducted into four meetings, with details of three meetings conducted the learning process, and one meeting was held distributing questionnaires of interest in learning mathematics.

One of the activity stages in the fun learning method is conditioning the atmosphere and learning environment by grouping or arranging interesting chairs. In this study, the researcher provided a theme in a fun learning atmosphere, for example, forming groups using the names of pirate captains because the theme was "Pirates". The given theme was conducted to attract students' attention. Besides that, it also gave yells suitable to the theme, providing ice breaking to support interesting learning, and rewarding small gifts to support students' learning efforts. The stages fun learning method is applied to follow the following stages.

Table 5. The Stages of Applying the Fun Learning Method to Learning Mathematics (teacher and students' activities)

Activities Stage	Teacher Activities	Students Activities
Conditioning: Condition the learning atmosphere and environment, such as forming groups or arranging attractive seats.	Arranging the learning environment according to students' preferences and comfort, motivating students, and talking intimately and humorously.	Arranging the learning environment with the teacher, interacting comfortably, generating self-motivation, and preparing for learning cheerfully
Exploration: Generating everyday experiences that all students can relate to.	Providing apperceptions about previous learning and relating with the topic to be	Listening to the teacher's apperception, engaging in concept exploration-

Activities Stage	Teacher Activities	Students Activities
	learned, providing contextual problems, and exploring concepts.	tion, and conveying new ideas
Material Presentation: Presenting the material learned using media that has exciting pictures and ice-breaking games.	Explain the material to be learned, provide ice-breaking, and then distribute the student worksheet to each group.	Paying attention to the teacher's explanation, playing icebreakers, completing the worksheets in groups, discussing, conveying new ideas, and getting actively involved during the discussion.
Demonstration Allowing students to show that they understand the material being taught.	Monitoring/ guiding students to work on the questions given.	Conducting demonstrations (presentation of group discussion results) and engaging in inter-group discussions.
The Last Stage: Giving directions to repeat the entire lesson and celebrating any achievements that students have shown during the learning process.	Providing good models and appreciation to students who complete mathematics tasks.	Receiving direction, fostering interest in repeating the material that has been learned, and celebrating the appreciation that has been given

Observing. During the learning process, the observer observes the activities carried out by the teacher and students. The observation aspect refers to the observation instrument. The data analysis on the percentage of students' activities observed during cycle 1 is presented in figure 2.

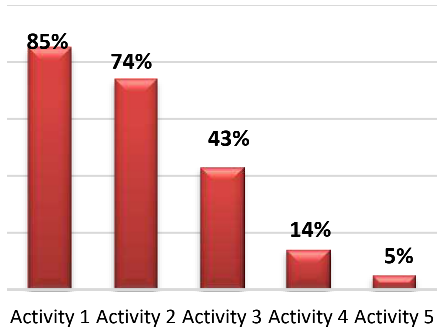

Figure 2. The Observation of Students' Learning Activities in Cycle I

Note:
Activity 1: Conditioning stages
Activity 2: Exploration stages
Activity 3: Material presentation stage
Activity 4: Performance stages
Activity 5: Final stage

Reflecting. In the last step of cycle 1 after the data is collected and analyzed, then the reflection is carried out. The reflection results are used as consideration in planning the next cycle. The data on Mathematics learning interests are gained by the questionnaires given to the students at the end of each learning cycle.

Table 6. Statistics Score Mathematics Learning Interest in Cycle I

Statistics	Scores
N	32
Mean	2.88
Maximum	4
Minimum	2
Range	2
Standard Deviation	0.707
Variance	0.500
Standard Error of Mean	0.125

If the student's interest score scores are grouped into five categories, the frequency, and percentage distribution are as follows.

Table 7. Distribution of Frequency of Mathematics Learning Interest in Cycle 1

Score Interval	Category	F	%
$4.50 \leq x \leq 5.00$	Very Good	0	0.0
$3.50 \leq x < 4.49$	Good	6	18.8
$2.50 \leq x < 3.49$	**Good Enough**	**16**	**50.0**
$1.50 \leq x < 2.49$	Fair	10	31.2
$1.00 \leq x < 1.49$	Poor	0	0.0
	N	32	

Table 7 shows that no students have a score of mathematics learning interest in the poor and very good category, 10 in the fair class, 16 in the good enough category, and 6 in the good category. The mean score of Mathematics learning interests of the students in cycle one is 2.88, so it can be concluded that the score of Mathematics learning interests of the students in cycle one is categorized as Good Enough.

The achievement of students' interest in learning mathematics in cycle one only reached 2.88 in the "good enough" category. In contrast, the frequency of active students was 44.2% is less than 75%, so they still need to fulfill the success indicators. After analyzing the data in cycle 1, it was concluded that the research was continued to cycle 2 to determine the achievement of the success indicators set in this study. The implementation of learning in cycle two is adjusted to the reflection that needs to be followed up, which includes.

Table 8. Cycle 1 learning reflection

No	Obstacles/ barriers	Improvements in cycle 2
1	Students are encouraged to choose where they study, either in or outside the classroom. It is a challenge for teachers to direct students	Learning activities are limited to the classroom environments to monitor students more effectively and control while still providing flexibility for students in expressing new ideas or ideas, involving more student participation in exploring concepts.
2	The ice-breaking provided could have been more varied, so some students felt bored or uninterested	Preparing more varied icebreakers

After analyzing data on cycle 1, the research continued to cycle 2 to determine the achievement of the success indicators set in this study. Next, cycle two was conducted according to the reflection in cycle 1, and some weaknesses should be improved.

The Data Presentation of Cycle 2

Cycle 2 was conducted in four meetings; three meetings conducted the learning process, and one meeting retrieved to deliver the questionnaire of learning mathematics interest.

Planning. At this stage, the researcher returned to planning to learn like cycle 1, but several important notes in cycle 1 needed to be improved in cycle 2, namely learning that increasingly attracted students' attention, and preparing research instruments to be used.

Implementing (action). In cycle 2 the application of the fun learning method is carried out almost the same as in cycle 1 where the researcher continues to provide it in the form of "treasures" so that students' curiosity can be maintained as in cycle 1 because the more enthusiastic students are in learning mathematics, the more influential they will be in increasing learning activities the math. In cycle 2, the steps of the fun learning method are applied in a more planned and thorough manner according to the stages. Fun learning methods developed in learning mathematics in 5 stages, namely (a) Conditioning Stages: The atmosphere and environment of teaching and learning activities can be conditioned by forming groups or arranging attractive benches, (b) Exploration Stages: It creates or brings about a common experience that all students can understand, (c) Material Presentation Stage: The teacher delivers the material learned using media, interesting pictures, and ice-breaking games, (d) Performance Stage: The teacher gives a chance to the student to show that they understand the material, (e) The Last Stage: The teacher gives directions to review the learning again and celebrate every achievement the students showed during the learning process. In cycle 2, the implementation of the fun learning method was like cycle 1, where the researcher still gave it as a "treasure" so that students' curiosity could be maintained as in cycle 1 because the more enthusiastic students have in learning mathematics, it will affect the increase in their mathematics learning activities.

Observing. In cycle 2, the fun learning method was applied almost the same as in cycle 1. Appreciating students is still provided in "treasure," so the students have curiosity and become more enthusiastic about learning mathematics which will certainly affect student activities. Student activity was analyzed in cycle two by using the student activity analysis formula. During the learning process, the observer observes the activities carried out by the teacher and students. The observation aspect refers to the observation instrument. The data analysis on students' activities observed in cycle 2 is presented in the following figure 3.

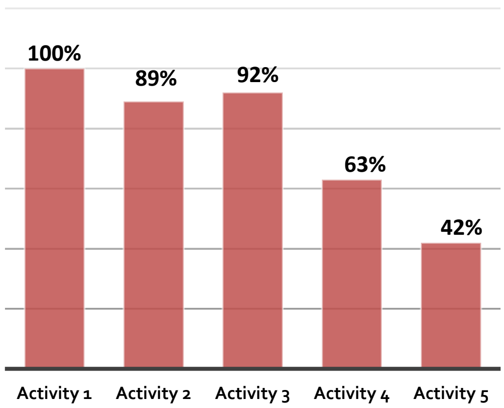

Figure 3. The Observation of Students' Learning Activities in Cycle 2

Reflecting. The implementation of learning in cycle two still follows the stages of the fun learning method; it is just that learning activities at certain stages are strengthened due to the low scores in cycle 1. For instance, at the exploration stage, students are given the flexibility to express their ideas. During the demonstration of work, they respond to each other between groups, engage in fun ice-breaking, and participate in appreciation. The learning process is centered in the classroom to facilitate the teacher to control and direct students in their learning activities.

In the last step of cycle 2 after the data has been collected and analyzed, then the reflection is carried out. The results of reflection on cycle 2 are very decisive because they will get an idea of whether the application of the fun learning method can increase students' interest in learning mathematics from cycle 1. Data on interest in learning mathematics are obtained from a questionnaire given to students at the end of each learning cycle.

The average percentage of student activity can be seen in Figure 3. The questionnaires about mathematics learning interests were provided at the end of the learning. Its result is explained as follows.

Table 9. Statistics Score Mathematics Learning Interest in Cycle 2

Statistics	Scores
N	32
Mean	4.0
Maximum	4
Minimum	4
Range	0
Standard Deviation	0.000
Variance	0.000
Standard Error Of Mean	0.000

If the student's interest score scores are grouped into five categories, the frequency, and percentage distribution are shown on Table 10.

Table 10. Distribution of Frequency of Mathematics Learning Interest in Cycle 2

Score Interval	Category	F	%
$4.50 \leq x \leq 5.00$	Very Good	0	0.0
$3.50 \leq x < 4.49$	**Good**	**32**	**100**
$2.50 \leq x < 3.49$	Good Enough	0	0.0
$1,50 \leq x < 2.49$	Fair	0	0.0
$1.00 \leq x < 1.49$	Poor	0	0.0
	N	32	100

In cycle 2, the researcher was provided more variations of ice-breaking than in cycle 1. In the same way, by conditioning the classroom atmosphere, the researcher gives students choices to work in a group based on student comfort. Then the appreciation that will be given to students is interestingly prepared so that students are more interested and enthusiastic about learning mathematics. The activity in cycle two was proven more effective. It can be seen from the increasing data on student interest in learning previously in the first cycle was in the "good enough" category, and cycle 2, was in the "good" category.

The Data Analysis of Learning Interests One of the students' works

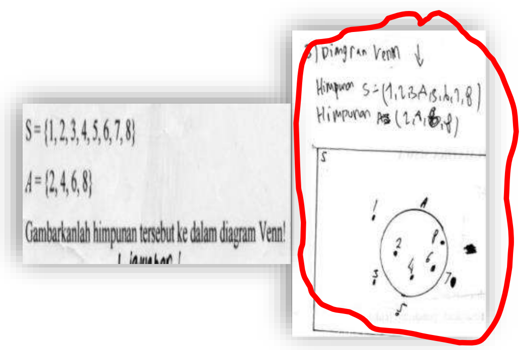

Figure 4. Student Work Samples

The test is given at the end of each cycle after the learning process is carried out using the fun learning method. The picture above results from student work on question number 3, which presents the set in a Venn Diagram. The stages of problem-solving can be carried out by students correctly, starting with identifying the known elements: Set S = {1,2,3,4,5,6,7}, Set A={2,4,6,8}. This step helps students determine the location of the members of set A in the universal set diagram. The next step is to draw a Venn Diagram. In this step, students begin to place the members of set A on set S. The members of the set A = {2,4,6,8} are placed inside the circle, while some members of the set "S" who are also not members of the set A are placed outside the circle, i.e. {1,3,5,7}. It can be concluded that students can present Venn Diagrams according to the known set members.

Based on the data analysis of cycle 1 and cycle 2, a comparison of the percentage of students' mathematics learning activity with the fun learning method was obtained. Figure 1 shows the activity mean score ratio in cycles one and two. The data was obtained based on the observation result conducted during the mathematics learning process.

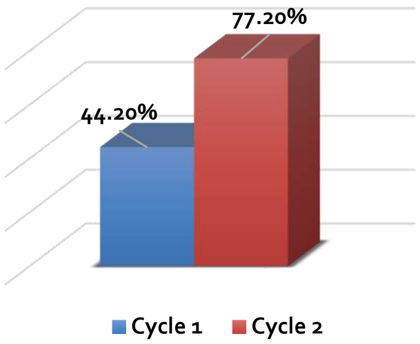

Figure 5. Percentage of Learning Activity Improvement

Quantitively the presentation of the activity from cycle 1 to cycle 2 shows the increase in a learning activity with a fairly good fun learning method by 33.00%. Specifically, the data analysis for each indicator of interest showed an increase from cycles 1 to 2. This condition indicated that the fun learning method could increase students' interest in learning mathematics.

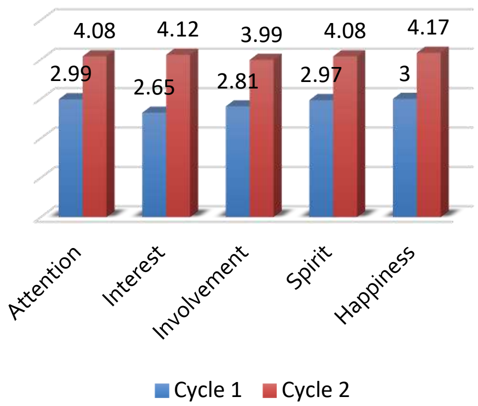

Figure 6. The ratio of the Interest Mean Score of Cycle One and Cycle Two

The reflection of learning in cycle 1 and cycle 2 showed that there was an achievement of the research indicator, including (1) increasing the average percentage of learning activities from cycle 1 by 44.20% to 77.2% in cycle 2, and (2) increasing the average percentage of student's interest in learning mathematics from cycle 1 by 2.88% to 4.08 in cycle 2. Analysis of the percentage of each interest indicator in cycle 1 showed an increase in cycle 2. Thus, the fun learning method can increase students' interest in mathematics. It indicates that an increase in fun learning could enhance students' interest in learning.

Reflection on cycle 2 shows the achievement of research indicators. The percentage of learning activities reached 77.2%, with an average score of interest in learning mathematics of 4.08 in a good category. The percentage of student activity increased by 33%, and the interest score exceeded the standard of 3.50. This condition indicates the achievement of the success indicators determined in the study, so it is not continued to the next cycle.

Significant student responses are shown in indicators of interest in the fun learning method and indicators of pleasure. The increased questionnaire score from cycle one to cycle two indicated that the fun learning method positively impacts students' interest in learning mathematics. Based on the data analysis of students' activities and learning interests from cycle I increased in cycle 2. Based on the data, it can be concluded that implementing the fun learning method in mathematics learning increases the mathematics learning interests of the VII_7 grade students at Junior High School 1 Pinrang South Sulawesi.

Discussion

The result of this study shows that the implementation of the fun learning method affects increasing students' interest in learning mathematics. The percentage of student activity increased by 33% from cycle 1 of 44.20% to cycle 2 of 77.20%, meaning that it met the criteria of 75% of the total students in the class, and the average student interest in learning mathematics was 4.08, meaning that it met the criteria of 3.50 in the good category.

An increase in students' interest in learning mathematics will have an impact on improving their learning achievement. It is supported by Purnomo et al. (2022), who explained that interest significantly impacts high and low student achievements in school. Besides the impact on students' achievements, interest also affects students' participation during the learning process. Setiawan et al. (2022) revealed that interest in learning would affect learning. The fun learning method helps students when receiving material is more fun and can train students to be more active and dexterous in solving a challenge. It is aligned with Sulistyo et al. (2021) that fun learning is intended for students to be more active and creative through some challenges.

Interest is a sense of liking and interest in a thing or activity without the presence of commands that can be expressed through statements that show a fondness for an item (Suwa et al., 2020). Interest is obtained through the learning process that arises from observing an object which results in a specific assessment of the thing that causes someone's interest. Interest in learning is also an aspect of motivation builder, a phenomenon that is formed because of social interaction, and student involvement in learning activities (Arwaty & Lullulangi, 2022). Interest is the awareness that accompanies and stimulates attention, feeling pleasant or painful, that directs attention to an action or object; in addition to that, interest is also a motivating factor that encourages the desire to take a step (Ijeoma & Rita, 2021). Interest is related to meaningfulness, where this aspect acts as a student's sincerity in understanding each learning topic at school. In fostering student interest in learning, a teacher needs to create personal meaning for each student with an exciting way of learning (Purnomo et al., 2022). Thus, students are expected to be able to apply to learn actively and creatively.

Safira *et al* (2017) stated that identifying the students' interests can be measured by: 1) Favorite, generally an individual who likes something because of their interest. Usually, what you want the most is easy to remember. It is the same with students who are interested in a specific subject and will like the subject. This favorite showed by the students' passion and initiative in attending the learning. 2) Interests, it can be found in the students who give reactions and responses to the teacher's explanation when the learning process in the classroom. The response shows that the teacher's explanation catches their attention, so there is great curiosity. 3) Attention: Every student interested in a field of science will tend to pay great attention to that subject. The student can easily understand the subject's point with this great attention. 4) Involvement in a process that requires student involvement, tenacity, and hard work. In this study, the indicators used to observe the students' interest in learning are (1) attention, (2) interest, (3) involvement, (4) spirit, and (5) happiness.

The involvement of students in learning hard, trying to find something new that is obtained from the learning process at school. The student in the learning activities will have the desire to develop knowledge, self-development, self-confidence, and Students in learning activities will have the desire to create understanding, develop self-confidence, and a feeling of curiosity. Interest plays an essential role in the learning process, so students will be able to achieve it (Suwa et al., 2020). Interest in learning is a person's tendency and focus on learning activities. Interest can be seen from the awareness that arises towards objects that are very liked and give birth to great attention for individuals (Jelita et al., 2022).

Changes in the learning process are variations in increasing interest in learning. The teacher needs to implement a fun learning method for students because the appropriate method will greatly support their learning activities. In addition, each student has different characteristics, which means that students with high, medium, or low learning interests also affect their understanding of learning topics (Purnomo et al., 2022). Therefore, implementing appropriate learning methods is essential in learning, as Wilkins (2021) reinforces that appropriate learning methods play an important role in monitoring and directing students' actions and reflecting on students in each learning process.

The finding in this study contributed to learning mathematics because the fun learning method is an innovative learning method that can increase the student's learning interest in learning mathematics. This method is expected to be implemented in various mathematics subject matter. The teacher can develop the method by using various mathematical aids or manipulative props that can stimulate students' interest in learning mathematics so that it is fun as revealed by Arumugham (2019) that a teacher takes help to develop fun learning for the students in a classroom setting. The success of the teaching and learning process cannot be separated from the role of teachers in varying methods (Hartini & Faridah, 2022). Fun learning has been a successful emerging trend for making effective learning. It has also been concluded that fun learning put a strong effect on enhancing students' creativity. Meaningful and fun activities can help students learn mathematics better. One way to create fun learning activities is by providing entertainment while learning. With the entertainment in learning, students will enjoy the learning activities so that the expected learning goal can be achieved (Putra et al., 2018).

The characteristics of the fun learning method are marked by: (1) conditioning students' learning environment, and in this case, the teacher will make small groups by giving group names in the form of names of plants, colors, objects, and others, this is the first step for students that they can grow their interest in the received lesson, (2) the use of media such as PowerPoint to show animation appropriated with the material that will be taught in every meeting, (3) prepare ice breaking. Ice-breaking can be provided when the class condition is not conducive anymore, and the students are bored with learning. Fun ice-breaking can be exciting so that it can recover the students' attention, concentration, and spirit. One of the ice-breaking in this study is "clap hand". According to Lestari et al. (2021), the implementation of icebreaking activities can increase learning interest. (4) celebrating the achievements that students have obtained during learning; in this case, the teacher appreciates the students with rapturous applause or other forms of joy such as giving small prizes for student success in education.

Interest is a tendency to pay attention and is related to the impulse that encourages students to be interested in certain things. Interest in learning mathematics has a fundamental role because it is a factor that affects the success of the intended achievement. Implementing the fun learning method for two cycles in this study is one of the strategies to increase student's interest in learning mathematics. The results showed an effect of the fun learning method on students' interest in mathematics because there was an increase in interest scores from cycle 1 to cycle 2. The results of this study indicate that students' interest in learning mathematics can be explored and increased when provided with the appropriate learning method.

In cycle 1, the fun learning method was implemented well enough according to its stages, but the results obtained had yet to reach the success indicator. Some critical notes because adaptation/conditioning is needed between students' learning habits and the methods used by teachers who do not activate/involve students in the learning process. As a result, students were passive and reflected a low interest in learning mathematics. These important notes became the reflection material for improvement in cycle 2. The stages fun learning method is applied to follow the following stages (See Table 11).

Table 11. The Stages of Applying the Fun Learning Method to Learning Mathematics (teacher and students' activities)

Activities Stage	Teacher Activities	Students Activities
Conditioning: Condition the learning atmosphere and environment, such as forming groups or arranging attractive seats.	Arranging the learning environment according to students' preferences and comfort, motivating students, and talking intimately and humorously.	Arranging the learning environment with the teacher, interacting comfortably, generating self-motivation, and preparing for learning cheerfully
Exploration: Generating everyday experiences that all students can relate to.	Providing apperceptions about previous learning and relating with the topic to be learned, providing contextual problems, and exploring concepts.	Listening to the teacher's apperception, engaging in concept exploration, and conveying new ideas
Material Presentation: Presenting the material learned using media that has exciting pictures and ice-breaking games.	Explain the material to be learned, provide ice-breaking, and then distribute the student worksheet to each group.	Paying attention to the teacher's explanation, playing icebreakers, completing the worksheets in groups, discussing, conveying new ideas, and getting actively involved during the discussion.
Demonstration Allowing students to show that they understand the material being taught.	Monitoring/ guiding students to work on the questions given.	Conducting demonstrations (presentation of group discussion results), and engaging in inter-group discussions.
The Last Stage: Giving directions to repeat the entire lesson and celebrating any achievements that students have shown during the learning process.	Providing good models and appreciation to students who complete mathematics tasks.	Receiving direction, fostering interest in repeating the material that has been learned, and celebrating the appreciation that has been given

The table above is a form of development conducted in this study because it is adjusted to the characteristics of students. The advantages of this method involve expressing ideas in a fun way, providing motivating ice breaks, creating a comfortable learning environment, and appreciating students' learning success. These techniques can arouse students' interest in learning if supported by teacher techniques to manage to learn well.

Implication

Learning mathematics by applying the fun learning method can increase the student's interest in learning mathematics in VII7 grade of Junior High School 1 Pinrang, South Sulawesi. Therefore, in learning, teachers should apply the fun learning method well and correctly according to the stages of the method.

Therefore, in learning, teachers should apply the fun learning method well and correctly according to the stages of the method. The application of the fun learning method affects student activities that are more active and creative in learning.

It has implications for achieving the intended learning objectives. The teaching actions conducted by the teacher and student activities in learning mathematics through the fun learning method provide an overview of the extent to which interest in learning mathematics could be increased. Fun learning, motivating ice-breaking, exploration of new concepts and ideas, functional performance, and celebrating appreciation can attract students' interest so that they enjoy learning mathematics. Increased student interest during the mathematics learning process will increase students' learning achievement.

Limitation

Some limitations in this study are: (1) learning materials are limited to the specific subject matter, so the meeting is only held four times in one cycle. (2). The flexibility given to students in learning outside the classroom in cycle one was challenging to control the teacher, so in cycle 2, the learning process with the fun learning method was centered only in the classroom. However, the fun learning method could be tested by other teachers with various modifications according to the situation and conditions in their class.

CONCLUSION

The fun learning method is a learning method that allows for creating an effective learning environment, creating a happy atmosphere in the learning process, making students more prepared and easier to learn, and even changing negative attitudes. The fun learning method eliminates the boring atmosphere and provides the joy of learning for students. This condition indicates that the fun learning method can increase mathematics learning interests. Indicators of improvement are shown in the increase in the percentage of student activity increased by 33% from cycle 1 at 44.20% to cycle 2 at 77.20%, meaning that it met the criteria of 75% of the total students in the class, and the average student interest in learning mathematics was 4.08, meaning that it met the criteria of 3.50 in the good category. This research is limited to mathematics learning, and its variable is learning interest. However, other variables can be developed, such as the effect of fun learning methods on learning outcomes, learning achievement, or the other variables that can contribute to education and learning.

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The Development of Problems for Minimum Competency Assessment Based on Ethnomathematics about Farmer Activities in Aceh Besar Regency

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Abstract

Minimum Competency Assessment or Asesmen Kompetensi Minimum (AKM) is used as a national assessment by involving several contexts in Indonesia; one of them is social culture. However, social cultural-based AKM problems, including ethnomathematics, are still limited. Therefore, efforts that can be carried out is designing ethnomathematics-based AKM problems related to farmers' activities. This study aimed to obtain problems for ethnomathematics-based AKM problems about farmer activities in one village, Aceh Besar Regency, Indonesia. This research is developmental research that was carried out through several stages, namely the preliminary, self-evaluation, prototyping, and the field test stages. In this case, the research subjects involved were 33 students of grade 8 at a junior high school in Aceh Besar. The data analysis technique used was the Aiken's V formula and the product moment correlation. The results obtained 10 problems for ethnomathematics-based AKM about farmer activities in Aceh Besar that achieved valid, practice, and had potential effects. The problems can be further used by mathematics teachers to improve the students' numeracy.

Keywords: AKM; Ethnomathematics, Problem Characteristics; Validation

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Abstrak

Asesmen Kompetensi Minimum (AKM) digunakan sebagai asesmen nasional yang melibatkan beberapa konteks, salah satunya sosial budaya. Namun soal AKM berbasis sosial budaya termasuk etnomatematika masih terbatas. Oleh karena itu, upaya yang dapat dilakukan yaitu merancang soal tipe AKM berbasis etnomatematika terkait aktivitas petani. Tujuan penelitian ini yaitu untuk memperoleh soal tipe AKM untuk kelas 8 berbasis etnomatematika terkait kegiatan petani di salah satu, Kabupaten Aceh Besar, Indonesia. Penelitian ini merupakan penelitian pengembangan dengan tahapan yaitu preliminary, self evaluation, prototyping, dan field test. Subjek penelitian ini yakni 33 siswa kelas 8 dari salah satu SMP di Aceh Besar. Teknik analisis data menggunakan formula Aiken's V dan uji korelasi product moment. Hasil penelitian berupa soal tipe AKM berbasis etnomatematika pada kegiatan petani di Aceh Besar sebanyak 10 soal yang valid, praktis, dan memiliki efek potensial. Soal tersebut dapat digunakan oleh guru matematika untuk meningkatkan numerasi siswa.

INTRODUCTION

In 2021, the implementation of the National Examination (NE) was changed to the National Assessment (NA). This is contained in the Regulation of Minister of Education, Culture, Research, and Technology No. 17 of 2021 issued on July 12, *2021*, related to the National Assessment (NA), stating that these activities are constructed to monitor and evaluate the primary and secondary school system. In this case, the skills and achievements of students are assessed by educators and units, not education (Kemdikbud, 2021).

Changes of assessment from National Examination (UN) into Asesmen Kompetensi Minimum (AKM) or Minimum Competency Assessment (MCA) is carried out by the Ministry of Education and Culture (Kemdikbud) as one of the efforts to improve the quality of education. In this case, AKM is the best method to serve the students' needs 1982). AKM tries to determine the minimum level that can be accepted by the learning achievement (Coates, 1994). In addition, AKM also becomes the basic or minimum competency assessment that is needed by the students to develop their self-capacity and positively participate in the society (Kemdikbud, 2020). There are three components in the National Assessments such as AKM Character Survey, and Learning Environment Survey (Pusat Asesmen dan Pembelajaran, 2021).

Reading literacy and numeracy of students are the benchmarks of the students' abilities, which are the objectives of the AKM instrument. AKM participants are all final year students who are respondents to the National Assessment from the fifth-grade elementary school, eighth grade junior high school, and eleventh grade high school classes. Thus, numeracy is one of the main focuses in improving the quality of Indonesian education, especially for better learning outcomes for students.

The components of reading literacy and numeracy contained in the AKM can be seen from three perspectives, namely: content, cognitive processes, and context. The aspects of the context of the numeration assessment in AKM cannot be separated from social and cultural aspects. *Education* is growing and providing many new colours in life. Innovations continue to emerge in the world of education *to* promote creativity and increase students' learning desires. This further affects math topics as well. Ethnomathematics-based mathematics learning is one of the innovations that have been designed to trigger the students' interest in learning mathematics. Ethnomathematics can be a bridge for mastering mathematics in students without leaving the cultural values they have (Lestari, 2019).

One of the relations between mathematics and tradition in an area can be seen in Aceh, which is better known as an area where *most* people work as farmers and use mathematics in carrying out their routine work as farmers. One of the areas in Aceh where many people work as farmers is Montasik, Aceh Besar Regency.

Many people do not realize that mathematics exists in culture and everyday life, hence learning mathematics can be more meaningful for students by linking contextual problems in learning (Sari et al., 2020). The relationship between contextual problems and culture can be stated in learning problems for students such as the AKM problems.

This study developed an ethnomathematical-based AKM which was used to assess the ability of students to deal with real world math problems related to the local context. This research was also carried out to continue previous research that has been carried out by Yanti (2022).

Various studies on development for junior high school students have been carried out, such as research conducted by Harnita, Johar, Hasbi, and Sulastri (2021) who developed problems with a disaster context, in addition to Wulandari, Hajidin, and Duskri who developed HOTS problems on algebra, and Ina (2020) who developed the PISA model of math problems, and Khofifah (2021) who developed mathematics with the context of Covid-19 for junior high school students.

Ethnomathematics-based development research has also been carried out, by Sutarto, Muzaki, Hastuti, Fujiaturrahman, and Untu (2022) who developed an Ethnomathematics-Based e-Module to Improve Students' Metacognitive Ability in 3D Geometry Topic, and Umbara, Wahyudin, and Prabawanto (2021) who conducted research on ethnomathematics, in which the community practices the dimensions of necessary universal mathematical activities, such as counting, placing, and explaining. Based on ethnomodeling, mathematical ideas and practices carried out are relevant to the concepts of enumeration, integer operations, sets, relations, congruence, and modulo.

Many attempts have been made to construct ethnomathematics-based problems in previous studies, but they have not met the characteristics of problems that are equivalent to AKM problems. This is also because the AKM just has been implemented since 2021 so that the AKM context is still new in education and further exploration is needed to achieve the expected AKM goals.

AKM is carried out to obtain information regarding the competency expected by the students (Kemdikbud, 2020). Teachers can use this competency assessment to develop an effective and qualified learning strategy. In addition, AKM is designed to produce information that can trigger the improvement of learning and teaching quality, that eventually can improve the students' learning achievement (Purnomo, Sa'adijah, Hidayanto, Sisworo, Permadi, & Anwar, 2022). Furthermore, teacher also claimed that ethnomathematical approach supports the students in improving their self-concept, improving their high-order thinking skill, as well as, making the material easier to understand (Fouze & Amit, 2018b; Utami et al., 2019).

Therefore, this study aimed to obtain AKM-based numeration problems for 8th grade on farmer activities in Montasik District, Aceh Besar Regency which meet the characteristics of valid problems and have potential effects. In this case, the research problems raised in this study are: 1) what are the valid characteristics of the AKM numeration problems for the 8th grade based on ethnomathematics in farmer activities in, Aceh Besar Regency? 2) what is the potential effect on numeracy problems of the AKM for 8th grade based on ethnomathematics on farmer activities in Aceh Besar Regency?

METHOD

The research was carried out through a *Research and Development* method, which is a systematic study in designing, developing, and evaluating a process, program, and product of teaching, that meet the criteria of validity, practicality, and effectiveness (van den Akker & Plomp, 1993; Seels & Richey, 1994; van den Akker,1999). The developmental model applied in this research is developmental research proposed by Tessmer (1993) which consists of two stages: the preliminary stage and the formative evaluation stage which consists of self-evaluation, prototyping (expert review, one-to-one, and small group), and field tests. The stages of development of Tessmer (1993) can be seen in the following Figure 1.

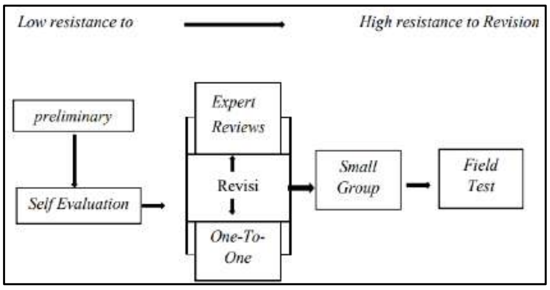

Figure 1 Tessmer Development Stages (1993)

This research was conducted at a junior high school in Montasik, Aceh Besar Regency, Indonesia involving 3 people at the one-to-one stage, 6 people at the small group stage, and 24 people at the field test stage.

The first stage is preliminary by conducting analysis (curriculum and materials) and literature studies on research development of mathematics problems with certain contexts, as well as determining the research schedule and procedures for collaboration with subject teachers at the school.

After carrying out the preliminary stage, the self-evaluation stage was carried out. The self-evaluation stage is the process of developing teaching materials that can be evaluated. At this stage, ethnomathematical-based for AKM-based problems were designed for the 8^{th} grade. Problem development was carried out by paying attention to three main things, namely content, construction, and language. The result of the design is referred to as prototype I.

Furthermore, in the second stage, namely expert review, prototype I was submitted to the validators or experts with the aim of validating the problems. This was done to examine the quality of instrument, which is to ask for experts or validator to conduct an assessment (Sireci, 1998). The validators involved in this study consisted of 3 people who were lecturers and teachers who had experience in developing contextual learning tools and understanding ethnomathematical concepts. The validator provided comments and suggestions on prototype I. After that, revisions were made to prototype I by considering input from the validator. The validator also provided scores and comments/suggestions on the validation sheet that has been provided.

Validity explains the level of goodness of the data collected, covering the real research area (Ghauri & Gronhaug, 2005). In addition, validity refers to assessing whether the element of the instrument is correct, relevant, reasonable, not ambiguous, and clear (Oluwatayo, 2012). The validity of the problems was measured by considering three aspects, namely the content, the construct, and the linguistic aspects. The results of the validator's assessment were analyzed using the Aiken's V formula. The problems are considered valid if the analysis results meet $0.667 \leq Va \leq 1$. The validity test on the ethnomathematics-based AKM problems

Table 1. Characteristics of Problems adapted from Lestari (2019) and Lewy, Zulkardi, & Aisyah (2009)

Content Aspect	Construct Aspect	Linguistic Aspect
Based on the aspect of content, the items developed include: Conformity with K13 basic competence (Revised 2017) Suitability of learning indicators Compatibility with education level Relevant to the ethnomathematics context in accordance with everyday life	Based on the aspect of the construct, the items developed include: Conformity between the construction rules of the problems and the form of the problem Clarity of the material on the problem Consistent font type and size Conformity between text and illustrations (such as pictures, tables, graphs, and diagrams) are presented clearly	Based on the language aspect, each problem developed includes: Good and correct use of Indonesian language Problems that are not convoluted Unambiguous Using spelling and punctuation marks in accordance with PUEBI (General Guidelines for Indonesian Spelling) Using language and terms that can be easily understood by students

that were developed have met the characteristics of the problems shown in Table 1.

The small group stage is to test the practicality of AKM problems involving six students. This stage produced prototype II and III, which were based on the students' feedback and ideas. In addition, prototype III was obtained during the field trial phase. This stage aimed to analyze the empirical validity and potential effect toward AKM problems.

The analysis of the empirical validity of the problems was carried out using the product moment correlation which was adapted from (Widoyoko, 2012). According to Widoyoko (2012), the instrument is considered valid if $r_{count} \geq r_{table}$ with a significant value = 0.05, and conversely the instrument is considered invalid if $r_{count} \leq r_{table}$. The interpretation of the magnitude of the correlation coefficient is presented in Table 2.

Table 2. Category of Empirical Validity

Coefficient	Category
$0.800 \geq 1.00$	Very High
$0.600 \geq 0.800$	High
$0.400 \geq 0.600$	Medium
$0.200 \geq 0.400$	Low
$0.00 \geq 0.200$	Very Low

(Arikunto, 2019)

Potencial effect was analysed based on students' response rtoward AKM problems using questionnaire. According to Khabibah (2006) and Kiswanto (2012), students' responses are positive if 70 percent or more of each indication is in the happy, new, and interested categories. The detail categories as shown in Table 3.

Table 3. Students' Response Criteria

Interval	Category
$85\% \leq RS_{media}$	Very Positive
$70\% \leq RS_{media} < 85\%$	Positive
$50\% \leq RS_{media} < 70\%$	Less Positive
$RS_{media} < 50\%$	Not Positive

(Khabibah in Kiswanto, 2012)

Table 2 shown most of students' response was positive. It concluded that the AKM problems have a potential effect.

RESULTS AND DICUSSION

The results of this study were AKM problems for the 8th grade based on ethnomathematics on farmer activities in Montasik District, Aceh Besar Regency. The design of problem was conducted to see the conformity between problems indicator with ethnomatematical context and the cognitive level on AKM, including *knowing*, *applying*, and *reasoning.*

The development of the problems was conducted through stages in accordance with Tessmer (1993) namely the preliminary and formative evaluation stages. The set of problems that have been developed consists of ten problems that have potential effects and met the characteristics of valid problems in accordance with the expected valid criteria.

Some of the development of ethnomathematics-based problems that have been carried out by previous researchers where there were no problems developed for the implementation of AKM. This is also because the AKM just has been implemented since 2021 so the AKM context is still new in education and further exploration of problems is needed to achieve the expected AKM goals. Thus, in this study the researchers concluded that it was necessary to develop ethnomathematics-based AKM problems for junior high school students to see the characteristics of valid problems that refer to students' mathematical reasoning abilities.

In the preliminary stage, the curriculum was analyzed to determine that the socio-cultural context, especially ethnomathematics is an important element that must be integrated optimally. Students' cultural values that are related to education must be integrated into learning process and established as a basic in developing the learning because social cultural is not only important for the humanity, but also for mathematics and science subjects (Simamora, Saragih & Siratuddin, 2019). Besides that, the socio-cultural context has not been fully included in the curriculum other than the content given by the teacher personally. In addition, material analysis was also carried out so that at this stage it was decided to take the material on numbers, geometry and measurements, algebra, data, and uncertainty which became the material domain in AKM numeration. The conclusion obtained at the preliminary stage is that it is necessary to develop an ethnomathematics-based AKM numeration problems. In addition, further exploration of problems related to the socio-cultural context is necessary.

The self-evaluation stage produced a set of numeration problems of the AKM for the 8th grade and the answer key with an ethnomathematical-based socio-cultural context on farmer activities in Montasik District, Aceh Besar Regency (prototype I) obtained ten problems. These problems consist of 5 problems on algebraic material (ratio & proportion and pattern numbers), 3 problems on geometry and measurement (flat shape and space), 1 problem on data and uncertainty (data and their representations), and 1 problem on a mixture of numbers with geometry and measurements (number operations and measurements).

The problems developed have been validated by the validator at the expert review stage and were declared valid entirely in terms of content, construct, and linguistic aspects. The validity of a problem can be seen based on the theoretical validity that must be met, such as content validity and construct validity (Arikunto, 2019). The results at the expert review stage are in line with research by Khofifah (2021), namely problems that are valid and feasible to use are problems that meet the content and construct aspects carried out by experts. This is in line with other research conducted by Harnita et al (2021) which stated that valid items are items that cover both content and construct aspects. At this stage, prototype I underwent revision on problems number 1 to number 7 as well as the stimulus problems to produce prototype II. Problems number 8, number 9, and number 10 did not undergo revision because according to the validator the three problems were

Table 4. The stimulus revision process for problems number 1 and 2 and problem number 1

Validator Comments	Revision Decision
In the Stimulus problem and problem number 1, the sentence "normal prices (before discounts) and discounts at shops in several villages" should be replaced with "normal prices (before discounts) and discounts in several villages" because the table does not contain information related to shop. In addition, the writing of Rp must not have a dot.	The researcher deleted the word shop and changed the sentence on Stimulus problem and problem number 1 to "normal price (before discount) and discount in several villages". The researcher also revised the correct writing of Rp according to PUEBI.

included in the very good category from the content aspect, the construct aspect, and the linguistic aspect. The process and results of the validation of several problems are as follows.

Problem Prototype I

One of the farming activities in Montasik District, Aceh Besar Regency carried out by the community is the provision of fertilizer. The following table shows a list of normal prices (before discount) and in-store discounts in several villages. All villages sell the same type of fertilizer.

Village	Discount			Unit Price (*sak*)		
	Urea Fertilizer	ZA Fertilizer	NPK-subsidi Fertilizer	Urea Fertilizer	ZA Fertilizer	NPK-subsidi Fertilizer
Weu Krueng	25%	10%	15%	IDR 150,000	IDR 120,000	IDR 160,000
Alue	20%	15%	10%	IDR 150,000	IDR 120,000	IDR 160,000
Warabo	15%	20%	25%	IDR 150,000	IDR 120,000	IDR 160,000
Seumet	10%	25%	20%	IDR 150,000	IDR 120,000	IDR 160,000

Source: Yanti (2022)

Pak Umar wants to buy each type of fertilizer per 1 *sak* at a shop in the same village. In order to get the cheapest price, the village that Pak Umar must visit to shop is...

a. Weu Krueng
b. Alue
c. Warabo
d. Seumet

Problem Prototype I after revision

One of the farming activities in Montasik District, Aceh Besar Regency carried out by the community is the provision of fertilizer. The following table shows a list of normal (before discount) and discount prices in several villages. All villages sell the same type of fertilizer.

Village	Discount			Unit Price (*sak*)		
	Urea Fertilizer	ZA Fertilizer	NPK-subsidized Fertilizer	Urea Fertilizer	ZA Fertilizer	NPK-subsidized Fertilizer
Weu Krueng	25%	10%	15%	IDR150.000,00	IDR120.000,00	IDR160.000,00
Alue	20%	15%	10%	IDR150.000,00	IDR120.000,00	IDR160.000,00
Warabo	15%	20%	25%	IDR150.000,00	IDR120.000,00	IDR160.000,00
Seumet	10%	25%	20%	IDR150.000,00	IDR120.000,00	IDR160.000,00

Source: Yanti (2022)

Pak Umar wants to buy each type of fertilizer per 1 *sak* in the same village. In order to get the cheapest price, the village that Pak Umar must visit to shop is...

a. Weu Krueng
b. Alue
c. Warabo
d. Seumet

Table 5. Revision process for problem number 2

Validator Comments	Revision Decision
In problem number 2, the sentence "the price of 1 *sak* of urea after the discount is the cheapest in Weu Krueng village" should be replaced with "the cheapest price of 1 sak of urea after the discount is in the village of Weu Krueng".	The researcher replaces the sentences according to what is suggested by the validator.

Problem Prototype I

The following statements relate to the purchase of fertilizer in Weu Krueng village. Put a tick (√) on each correct statement!

- ☐ Buying 3 *saks* of urea fertilizer in Weu Krueng village at a normal price is the same as buying 4 *saks* of urea fertilizer at a discount.
- ☐ The price of 1 *sak* of urea fertilizer after the discount in Weu Krueng village is the cheapest, as well as the price of 1 *sak* of ZA fertilizer and 1 bag of subsidized NPK fertilizer after the discount.
- ☐ The discount on the purchase of 2 *saks* of urea fertilizer in Weu Krueng village and 2 *saks* of ZA fertilizer is the same as the price of 1 bag of urea after the discount in the same village.

Problem Prototype I after revision

The following statements are related to the purchase of fertilizer in Weu Krueng village. Put a tick (√) on each correct statement!

- ☐ Buying 3 *saks* of urea fertilizer in Weu Krueng village at normal price is the same as buying 4 *saks* of urea fertilizer at a discount.
- ☐ The cheapest price for 1 *sak* of urea after the discount is in Weu Krueng village, as well as the price of 1 *sak* of ZA fertilizer and 1 bag of subsidized NPK fertilizer after the discount.
- ☐ The discount on the purchase of 2 *saks* of urea fertilizer in Weu Krueng village and 2 *saks* of ZA fertilizer is the same as the price of 1 bag of urea after the discount in the same village.

Changes on sentences were also carried out in the problems revision so that the sentence became more communicative and were not ambiguous. Ambiguous sentence has more than one meaning, hence causing unclearity. In order that the sentences constructed can be accpeted well, the sentence must use Indonesian language that are good, correct, standard, and in accordance with the PUEBI (Riswati, 2015).

Table 6. Revision process for problem number 5

Validator Comments	Revision Decision
In problem number 5, some punctuation marks should be paid more attention, such as the sentence "to fence the land is too long" should be given a period (.) and then followed by the following sentence, and so on.	The researcher revised some punctuation marks that were considered inappropriate in sentences.

Problem Prototype I

A farmer will fence his nursery in the form of a square with an area of p^2 m^2, but the net available to fence the land is too long so the farmer changes the shape and size of his nursery. If the length of the nursery is extended by 8 m and the width of the nursery is reduced by 3 m. What is the area of the new nursery area?

Problem Prototype I after revision

A farmer will fence his nursery in the form of a square with an area of p^2 m^2, but the net available to fence the land is too long. So, farmers change the shape and size of their nursery. If the length of the nursery is extended by 8 m and the width of the nursery is reduced by 3 m, what is the area of the new nursery?

The results of the validity score of the problems from experts is shown on Table 7.

Table 7. The Score of Validation from Validators or Experts

Assessment Aspect	Score			Analysis Process						
	Va-1	Va-2	Va-3	S1	S2	S3	ΣS	n(c-1)	CV1	Criteria
S (1)	5	5	4	4	4	3	11	12	0.9167	Valid
S (2)	5	5	4	4	4	3	11	12	0.9167	Valid
S (3)	4	5	5	3	4	4	11	12	0.9167	Valid
S (4)	5	5	4	4	4	3	11	12	0.9167	Valid
S (5)	4	5	4	3	4	3	10	12	0.8333	Valid
S (6)	4	5	3	3	4	2	9	12	0.75	Valid
S (7)	5	5	4	4	4	3	11	12	0.9167	Valid
S (8)	4	5	4	3	4	3	10	12	0.8333	Valid
S (9)	5	5	4	4	4	3	11	12	0.9167	Valid
S (10)	5	5	5	4	4	4	12	12	1	Valid
S (11)	4	5	4	3	4	3	10	12	0.8333	Valid
S (12)	5	4	4	4	3	3	10	12	0.8333	Valid
S (13)	4	4	5	3	3	4	10	12	0.8333	Valid
S (14)	4	5	5	3	4	4	11	12	0.9167	Valid
S (15)	4	5	4	3	4	3	10	12	0.8333	Valid
S (16)	5	5	5	4	4	4	12	12	1	Valid
S (17)	4	5	4	3	4	3	10	12	0.8333	Valid
S (18)	5	5	5	4	4	4	12	12	1	Valid

(Description: S = statement)

Furthermore, based on the results of student answers and student comments at the one-to-one stage and the small group stage (prototype III), it was stated that students had understood the problems developed. Thus, the problems have been read and can be understood by students. In line with the research conducted by Kamid et al, (2021) which measured the practicality of the problems through the ability of students to understand the problems, it was easy to read and understand, and the context used was recognized by students. In one-to-one and small group, students solve the problems completely as seen on Figure 2.

Prototype III was tested on 24 students in grade 8 in a junior high school in Montasik. The field test was conducted on the grounds of analyzing the empirical validity and potential effect of the problems through the results of the students' scores. The empirical validity (r_{xy}) of the developed problems resulted in an average value of $r_{xy} > r_{table}$ with a significant level of 5%, where r_{table} is 0.404. The results of the empirical validity of the problems can be seen in Table 8.

Table 8. The Empirical Validity of Problems

No.	r_{xy}	$r_{tabel} = 0{,}404$	Conclusion
1.	0.667	$r_{xy} > r_{tabel}$	Valid
2.	0.417	$r_{xy} > r_{tabel}$	Valid
3.	0.662	$r_{xy} > r_{tabel}$	Valid
4.	0.492	$r_{xy} > r_{tabel}$	Valid
5.	0.825	$r_{xy} > r_{tabel}$	Valid
6.	0.503	$r_{xy} > r_{tabel}$	Valid
7.	0.435	$r_{xy} > r_{tabel}$	Valid
8.	0.466	$r_{xy} > r_{tabel}$	Valid
9.	0.566	$r_{xy} > r_{tabel}$	Valid
10.	0.695	$r_{xy} > r_{tabel}$	Valid

Based on Table 8, it is concluded that, all problems have met the valid criteria. This is in line with research conducted by Khofifah (2021) who developed problems and each item was declared valid, that ethnomatematics-based questions are important to be developed. There is a change on the students' perspectives concerning the mathematical relationship with the real and cultural situation around

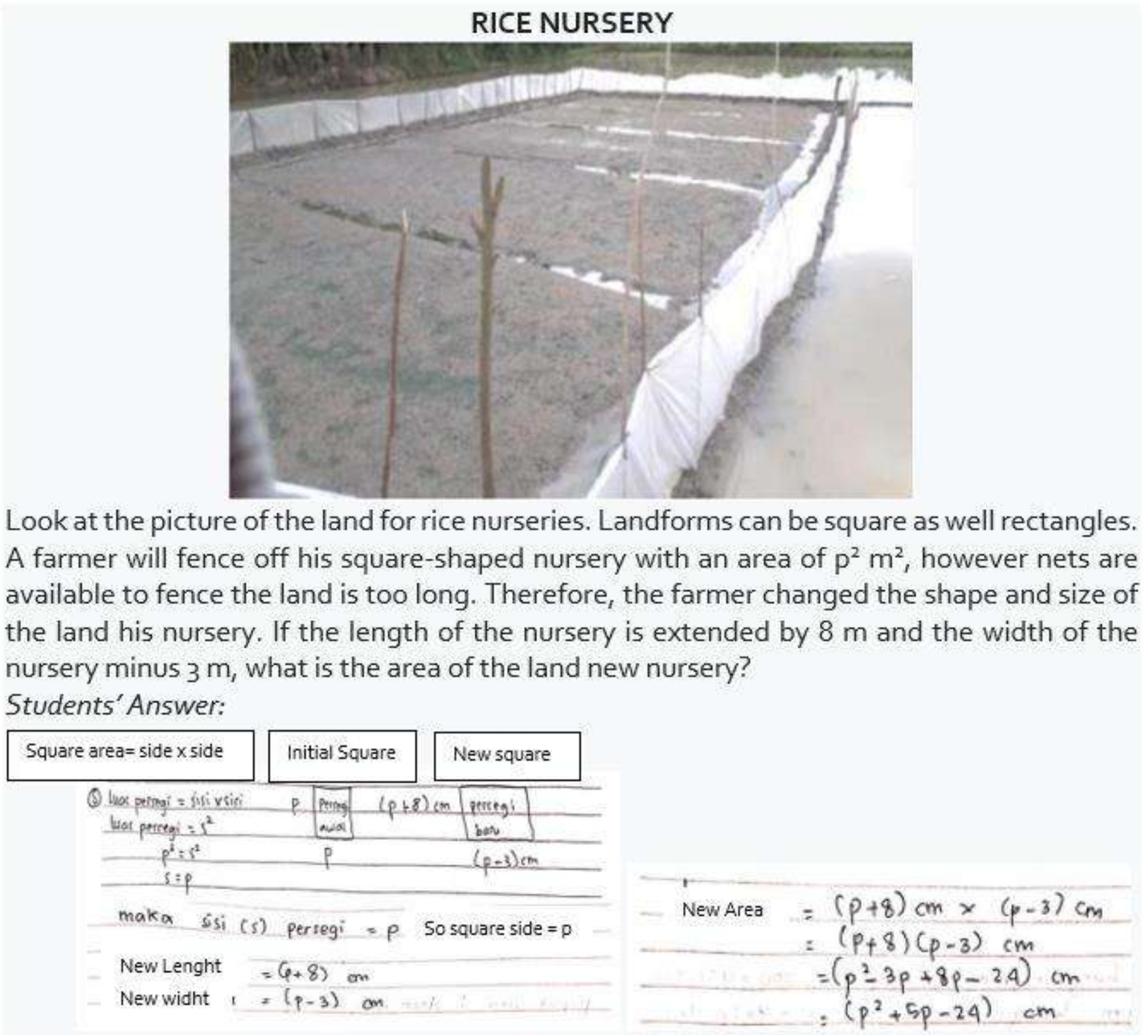

Figure 2. Problem 5 about rice nursery problem and students' answer

the students after learning mathematics using ethnomathematics exploration. This can further improve the students' comprehension and cause the students to think that the mathematics subject they learnt is meaningful (Prahmana & D'Ambrosio, 2020). Furthermore, students are also happier because they can solve the mathematics problems closer to their real world (Purwanti, 2012).

This study also analyzed the students' response questionnaires given at the field test stage as additional information about the potential effect on student interest in using the developed AKM problems. Questionnaire is a tool used to collect data by asking respondents to provide written answers to statements that have been given by users (Widoyoko, 2012). The results of students' response to questionnaire can be seen in Table 9.

Table 9. Students' Response to Questionnaire Results

No	Aspects	Responses		Category
1.	What do you think of the components:	New	Not New	
	a. The AKM has a socio-cultural context in farmer activities in Montasik District, Aceh Besar Regency given	100%	-	Very Positive
	b. The material presented in the AKM has a socio-cultural context in farmer activities in Montasik District, Aceh Besar Regency	75%	25%	Positive

No	Aspects	Responses		Category
	c. The socio-cultural context presented in the AKM problems is the activities of farmers in Montasik District, Aceh Besar Regency	70.83%	29.17%	Positive
	d. The form of the problems presented in the AKM has a socio-cultural context in farmer activities in Montasik District, Aceh Besar Regency	75%	25%	Positive
	e. The contextual problem presented in the AKM has a socio-cultural context in farmer activities in Montasik District, Aceh Besar Regency	70.83%	29.17%	Positive
2.	What do you think about the problems?	Yes	No	
	a. Is the socio-cultural context presented relevant to your previous knowledge?	70.83%	29.1%	Positive
	b. Are the problems related to everyday life?	87.5%	12.5%	Very Positive
	c. Is the supporting information in the problems, such as pictures, graphs, tables, diagrams, presented clearly?	87.5%	12.5%	Very Positive
	d. Is the writing of the type and size of the letters in the problem consistent?	95.8%	4.2%	Very Positive
	e. Are the instructions on how to answer the problems clearly written?	87.5%	12.5%	Very Positive
	f. Can you understand the use of language in each sentence in the problem well?	95.8%	2.2%	Very Positive
	g. Does the socio-cultural context make learning and taking tests such as the AKM less boring?	75%	25%	Positive
	h. Does socio-cultural context encourage you to explore more about the culture in your area	75%	25%	Positive
	i. Do you like the idea of a Minimum Competency Assessment that is being implemented in education in Indonesia today?	87.5%	12.5%	Very Positive
3	Are you interested in participating in other AKM activities with a socio-cultural context?	Interested	Not Interested	
		87.5%	12.5%	Very Positive

Based on the results of the questionnaire analysis presented in the Table, 8 aspects of the assessment measured in the questionnaire are in the very positive category (85% ≤ RS_{media}) and 7 other aspects of the assessment are in the positive category (70% < RS_{media} < 85 %). The quality of product is determined by the students, where the students appreciated the product and have willingness to use them (Nieveen, 1999).

The results of the questionnaire showed that the ethnomathematics-based AKM problems on farmer activities in Montasik District, Aceh Besar Regency are considered to have a potential effect which refers to the interest of students in the problems because more than 70% of students respond with new, happy, and interested larger than the problem being developed. In this case, High school students like to study through props that connect geometry and culture (Verner, Massarwe & Bshouty, 2019).

Based on the results of ethnomatematics-based AKM problems development on farmers' activities in Aceh Besar Regency, it obtained 10 problems that have met the valid criteria. In addition, based on the students' answers and comments on the one-to-one and small group discussion stages, the problems have met the practical criteria and to have a potential effect which refers to the students' response toward the problems. In this case, the results of the quality of learning development product must met the criteria of validity, practicality, and effectiveness (Nieveen, 1999).

Furthermore, the limitation of the current research was on the *field test* stage where several students did not answer the problems that have been developed so that these students were not involved in the analysis. In addition, students also share their comment during *one-to-one* and small group discussion stages that several problems developed were too long, so the researcher tried to minimize them by making a shorter stimulus for the two problems. However, not all stimulus of problems can be shortened since all the information is needed.

CONCLUSSION

This study results in a package of numeration problems of AKM for the 8th grade based on ethnomathematics on farmer activities in Montasik District, Aceh Besar Regency which have met the valid criteria in terms of content, construct, and language aspects according to experts. In addition, **this problem** also met empirical validity based on the test carried out to students. The problems developed have various problems namely 2 multiple choice problems, 3 complex **multiple-choice** problems, 2 long answer problems, 2 short answer problems, and 1 matching problem. Based on student response to problem, it can be concluded that AKM problems based on ethnomathematics about farmer activities have a potential effect which refers to the interest of students to the problems raised. In this case, the problems can be used further by the mathematics teacher as an instrument to improve the junior high school students' numeration skill.

This research wasconducted on the validity, practicality and have potential effect. Future researcher is expected to continue the research to test the effectiveness of AKM problem. Meanwhile, the implication of this research is in the forms of valid problems that have potential effects to be used by teachers in teaching and learning process in the classroom.

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The Reflective and Impulsive Graduate Student's Creativity Problem Solving of Three Variables of Linear Equations System

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Abstract

The challenge for prospective mathematics teachers in the future is to have a good mastery of the material, be able to solve math problems and think creatively. So that later they will be able to guide their students to develop creativity in 21st-century life. Cognitive style and learning influence the establishment of the creativity of mathematical problem-solving. The purpose of the study was to describe the creativity of students with reflective and impulsive cognitive styles in solving problems of a three-variable linear equation system. The research was carried out using descriptive-qualitative research methods. The research subjects were the Mathematics Education Study Program students at the University of Palangka Raya. The research instrument uses the Matching Familiar Figure Test, a problem-solving ability test, and an analytic rubric. Data were analyzed by scatterplot, pie diagram, reduction, triangulation, and inference. Research findings on students with reflective cognitive style in stages (1) understand problems and develop mathematical models with fluency, flexibility, originality, and elaboration; (2) complete the plan with fluency, flexibility, and elaboration; (3) check the results with fluency and elaboration. Students with impulsive cognitive styles are only in the stage of understanding the problem with fluency, novelty, and elaboration indicators.

Keywords: *creativity, impulsive, linear equation system, problem-solving, reflective*

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Abstrak

Tantangan bagi calon guru matematika di masa depan harus menguasai materi, mampu memecahkan masalah matematika dan kreativitas berpikir yang baik. Agar nantinya mereka mampu membimbing para siswanya mengembangkan kreativitas dalam kehidupan abad 21. Gaya kognitif dan pembelajaran berpengaruh terhadap pembentukan kreativitas memecahkan masalah matematika. Tujuan penelitian mendeskripsikan kreativitas mahasiswa dengan gaya kognitif reflektif dan impulsif memecahkan masalah sistem persamaan linier tiga variabel, Penelitian dilaksanakan dengan metode penelitian deskriptif-kualitatif. Subjek penelitian adalah mahasiswa Program Studi Pendidikan Matematika Universitas Palangka Raya. Instrumen penelitian menggunakan Matching Familiar Figure Test, tes kemampuan pemecahan masalah dan rubrik analitik. Data dianalisis dengan scatterplot dan pie diagram, reduksi, triangulasi dan penyimpulan. Temuan penelitian pada mahasiswa dengan gaya kognitif reflektif pada tahap-tahap (1) memahami masalah dan menyusun model matematika dengan kefasihan, keluwesan, kebaharuan, dan elaborasi; (2) menyelesaikan rencana dengan fasihan, keluwesan, dan elaborasi; (3) memeriksa hasil dengan kefasihan dan elaborasi. Mahasiswa dengan gaya kognitif impulsif hanya tahap memahami masalah dengan indikator kefasihan, kebaharuan, dan elaborasi.

INTRODUCTION

Background

The challenges of learning 21st-century for prospective mathematics teachers are required to be able to carry out Technological, Pedagogical, and Content Knowledge (TPACK). Mathematic learning should develop mastery of critical thinking, creativity, collaboration, and communication skills. Mastery of content knowledge and creativity in solving mathematical problems is very important for students to master. These competencies are the provision for students to become future teachers of mathematics. According to Wijers & de Haan (2020) and Guinungco & Roman (2020), the skill of solving math problems is one of the important thinking skills to be mastered by students. Meanwhile, according to Marliani (2015) and Wilda et al. (2017), creativity has a positive effect on mathematics mastery and problem-solving.

Creative thinking is related to efforts to find solutions to everyday life problems. The three-variable linear equation system (TVLES) can be used as a tool to explore ideas for solutions to everyday problems. TVLES is material studied in Algebra lectures. One of the goals of studying TVLES is to solve everyday life problems. During the learning process, the process of understanding the concept and solving TVLES problems is also formed. In this case, the TVLES problem-solving process requires creative thinking. Creativity contributes to the thinking process of understanding mathematics both from the aspect of mastering the material and solving mathematical problems.

Creative thinking skills have been formed during students are working on learning assignments. The results of previous research show that creativity can be formed through the process of learning mathematics. Creative thinking is influenced by the level of students' mathematical abilities. Research by Suripah & Sthephani (2017) shows that in solving cube roots of complex equations, students with a high level of mathematical ability are able to master all indicators of creativity. The results of this study indicate that the factor of mathematical ability levels influences student creativity in solving complex equation roots problems. Likewise, the results of research by Malekian & Fathi (2012) and Kwon et al. (2006) planning, implementing, and using mathematics learning strategies affect creativity in learning mathematics. Wulandari et al. (2016) found that the cognitive style and creativity of Bandung Institute of Technology students were significantly correlated with the achievement index.

Creativity in solving math problems in students is influenced by the characteristics of thinking. One of the characteristics of thinking is cognitive style, which influences students' creativity in understanding and solving mathematical problems. According to Marliani, (2015), cognitive style is one of the individual characteristics. Cognitive style is a tendency in terms of feeling, remembering, organize, process, and solve problems, to distinguish, understand, store, and inform. Cognitive styles according to experts, such as Kagan et al. (1964), Kagan (2016), and Rozencwajg & Corroyer (2005) classified two types of cognitive styles, namely reflective and impulsive.

Reflective individuals tend to take time to think before planning an action. Meanwhile, individuals who are impulsive tend to respond more directly. Warli (2010) states that there are significant differences in the mathematical abilities of students whose cognitive style is reflective higher than impulsive.

Cognitive style as a tendency to process information influences individual creativity in solving mathematical problems. Types of thinking styles affect the level of student creativity in solving math problems (Purnomo et al., 2017) . It's related to the research of Warli (2010) state that there are significant differences in the mathematical abilities of students with a higher reflective cognitive style than impulsive ones. So the style of thinking affects the creativity of thinking in solving mathematical problems.

This opinion implies that the creative thinking of students in solving TVLES problems will also be influenced by the characteristics of reflective and impulsive thinking styles. Thinking processes that tend to be reflective and impulsive will provide ample space for students to read, understand, and explore mathematical models to solve TVLES problems. The TVLES problem requires a careful understanding of its meaning. The problem is whether the learning process through lecturing can support the creativity of Mathematics education students to solve mathematics problems.

This study focused on finding profiles of students' mathematical thinking creativity in solving problems related to TVLES in terms of the characteristics of reflective and impulsive cognitive styles. In line with the research focus, the research objectives were to describe (1) students' creative thinking abilities with a reflective cognitive style and (2) students' creative thinking abilities with an impulsive cognitive style in solving TVLES problems. In the following, a theoretical construction of creativity in solving TVLES problems and cognitive style is built.

Theoretical Framework

Creative Thinking

Creativity according to Pehkonen (1997) is an individual's ability to produce something new and unpredictably. Minchekar (2017) defines creativity as a process of obtaining valuable original and renewable ideas. Wulandari et al. (2016) state that creativity is a person's ability to deal with a situation that is difficult to overcome with new ideas that are adaptive to difficulties. These definitions to stated that creativity is an individual's ability to find new ideas that are valuable in getting a solution to a problem. Creative thinking in learning mathematics is a process of thinking by bringing up new ideas or combining ideas that were previously done.

Indriyani et al. (2020) define the ability to think creatively as an individual's mental process of generating ideas smoothly, flexibly, and in detail. According to Siswono (2005), the process of creative thinking is related to the process of compiling ideas, building ideas, and planning and implementing these ideas to get a new product. Based on this definition, mathematical creative thinking is an individual mental process of creating new ideas in solving problems related to mathematics. These new ideas can be accepted as mathematically correct and created smoothly, flexibly, and flexibly.

Relevant to this explanation Nurhayati & Rahardi (2021) state the ability to think creatively mathematically is the ability to find solutions to mathematical problems in a simple and flexible manner. In addition, creative thinking is an original cognitive ability in the process of solving mathematical problems. According to Kwon et al. (2006), Marliani (2015), Minchekar (2017), Purnomo et al. (2017), and Yulianto et al. (2021) the ability to think creatively mathematically can be interpreted as the ability to solve mathematical problems with more than one completion of thinking fluency, flexibility, elaboration, and originality in the answers. From the opinion above, it can be concluded that there are four key elements of mathematical creative thinking, namely fluency, flexibility, originality, and elaboration. These four key elements of creativity need to be formed in students' thinking when participating in learning for mathematics courses.

Problem-Solving Skills

The problem-solving process produces a way to organize problem situations that produce good problem-solving structures and contain the achievement of problem-solving goals. Mathematical problem solving is a thinking process by integrating concepts, theorems, principles, and Mathematical axioms in a problem situation to be solved, and producing a form of mathematical problem solving that has true value based on mathematical logic.

Schoenfeld (2016) describes the math problem-solving strategy put forward by Polya as follows. First, the process of understanding the problem through the activity of compiling questions from the problem situation. Second, making a problem-solving plan is carried out by determining the components or data, or information one by one. Third, solving the problem is carried out by transforming the problem statement into a mathematical model and completing mathematical calculations. Fourth, reviewing the problem by examining the results of solving the questions that have been formulated previously. Based on the stages of solving these problems, the indicators of mathematical problem-solving ability are understanding the problem, developing a solving plan, completing the plan, and checking again.

Reflective-Impulsive Cognitive Styles

Cognitive style is a person's unique way of learning, both related to how to receive and process information, attitudes toward information, and habits related to the learning environment (Zakiah, 2020). Individual differences that persist in how to compile and process the information on these experiences are known as cognitive styles (Fadiana, 2016).

Kagan et al. (1964), Kagan (2016), and Rozencwajg & Corroyer (2005) classify cognitive styles into two categories, namely reflective and impulsive. The reflective individual has the characteristic of thinking about solving problems for a long time, but carefully so that the answers given tend to be correct. The Impulsive individual thinks solving problems in a short time, is less thorough, so the answers tend to be wrong. So, there are two important aspects of the reflective and impulsive cognitive styles, namely the time and correctness of the answers used by students to solve problems. Lahinda & Jailani (2015) stated that cognitive style acts as cognitive control.

METHOD

This research was carried out using a qualitative-quantitative mixed method (Creswell, 2020), which focused on describing students' reflective and impulsive thinking creativity in solving TVLES problems. The qualitative descriptive method was carried out by describing the reflective and impulsive subject's creativity in solving TVLES problems. While the quantitative descriptive method is used to classify subjects according to cognitive style. The research phase follows the flow of activities according to Elo et al. (2014) to ensure the trustworthiness of research findings, as presented in Figure 1.

Figure 1. The Research Phases

The preparation phase includes the activities of choosing data collection methods, how to choose subjects, and units of analysis. Methods of data collection using tests and interviews, to ensure the credibility of data collection as stated Elo et al. (2014) can be done by a combination of the two methods. Cognitive style tests using the Matching Familiar Figure Test (MFFT) by Kagan et al. (1964) which was updated to MFFT-2021 and has good validity and reliability according to (Viator et al., 2022). Creativity in solving TVLES problems is explored by testing TVLES's problem-solving abilities. The answers of the research subjects were analyzed using the rubric of mathematical problem-solving skills and the rubric of thinking creatively. The interview instrument was in the form of a list of questions about mathematical problem-solving abilities and creativity. The stages of data collection are method and theoretical triangulation techniques (Elo et al., 2014).

The research subjects were determined using a purposive sampling technique (Elo et al., 2014), where the research subjects were selected according to the research objectives. The research subjects were selected by purposive sampling from students of the Mathematics Education Study Program, Teacher Training and Education Faculty of University Palangka Raya, who had taken Algebra courses and were currently taking School Mathematics III course of 34 students. The selection of subjects has fulfill transferability (Stahl & King, 2020), where the same subject, context, and experience can also be found in the context of lectures at other campuses that educate prospective Mathematics teachers.

The organizational phase includes categorization and abstraction, interpretation, and representativeness analysis. The organizational phase was carried out on the cognitive style data by giving the MFFT test to 34 subjects individually. The results of categorization, abstraction, and interpretation services as a reference for selecting each subject with the highest reflective cognitive style and the lowest impulsiveness. In this way, the representation of research subjects is fulfilled.

According to Denzin and Lincoln (2005), data interpretation should use adequate criteria. The abstraction and interpretation of the MFFT test results use the criteria for classifying cognitive style according to the quadrants with the median time (t) and f (right choice frequency) axes presented in Figure 2 and the cognitive style criteria in Table 1.

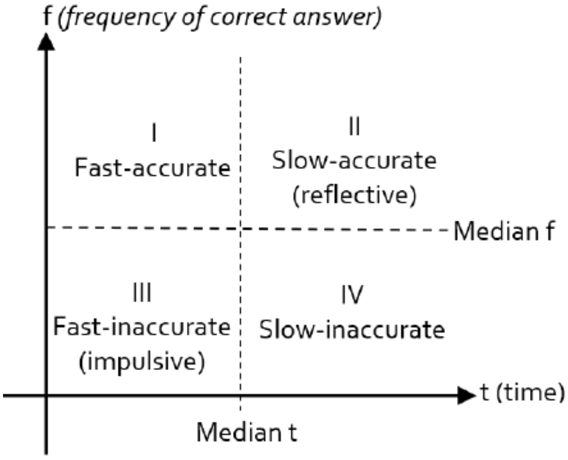


Figure 2. Reflective-Impulsive Quadrants

Table 1. The Cognitive Styles Categorization

Quadrant	Cognitive styles	Criteria
I	*Fast-accurate*	t ≤ median t f ≥ median f
II	*Slow-accurate (reflective)*	t ≥ median t f ≥ median f
III	*Fast-inaccurate (impulsive)*	t < median t f < median f
IV	*Slow-inaccurate*	t > median t f < median f

Subjects were grouped into four categories and their percentages were calculated according to the fast-accurate, slow-accurate (reflective), fast-inaccurate (impulsive), and slow-inaccurate categories. The next step is the reflective and impulsive subjects who are selected, doing the TVLES problem-solving ability test. Solutions to TVLES problems written on the answer sheet, reviewed, interpreted, and abstracted refer to the analytic rubric of creativity in solving TVLES problems. The identification results were deepened through the triangulation of sources by interviewing reflective and impulsive subjects, followed by interpretations and conclusions. The results of data analysis are presented with tabulations, scatterplots, pie diagrams, and problem-solving analyses of answers.

In the next stage, reflective and impulsive subjects were in-depth interviewed to fulfill the dependability and confirmability (Stahl & King, 2020). Analysis of TVLES problem-solving answers using an analytical rubric with the following stages. First, the ability of the two subjects to solve TVLES problems was analyzed according to Polya's stages of problem-solving (Schoenfeld, 2016). Second, the results of the analysis of TVLES's problem-solving abilities were analyzed again from the aspect of the emergence of problem-solving creativity indicators according to the stages of problem-solving.

RESULTS AND DISCUSSION

Results

The following presentation presents the results of an analysis of the ability to solve TVLES problems and the creativity of solving TVLES problems for reflective and impulsive students. TVLES problems are related to bank loans and bank interest issues, as well as years of historical events in Indonesia.

Cognitive Styles

There are 34 students who underwent the MFFT test, and 28 students only can answer all the test items. The results of the calculation analysis obtained a median answer time of 9.00 and a median correct answer score of 11.00. Then the distribution of MFFT score presented using a scatter plot. Which the median time at abscissa line and the median of MFFT score at ordinate line. Then result scatter plot identified students' cognitive styles and using a pie diagram presented the percentage of students grouping according to cognitive style can be presented in Figure 3 and 4.
There are 28 students identified who had a reflective cognitive style, 11 people (47%), 2 people (9%) were slow-inaccurate, 9 people (39%) were impulsive, and 6 people (5%) were fast-accurate. Students with a reflective cognitive style are characterized

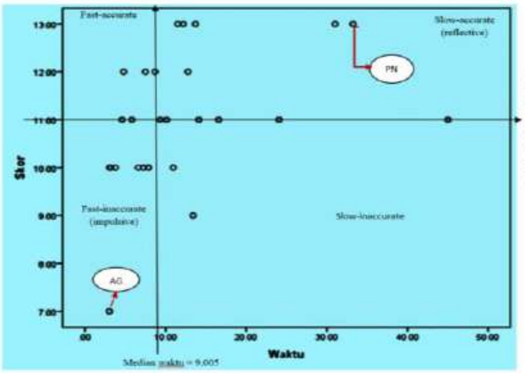


Figure 3. Scatter Plot of Cognitive Styles of 28 Students

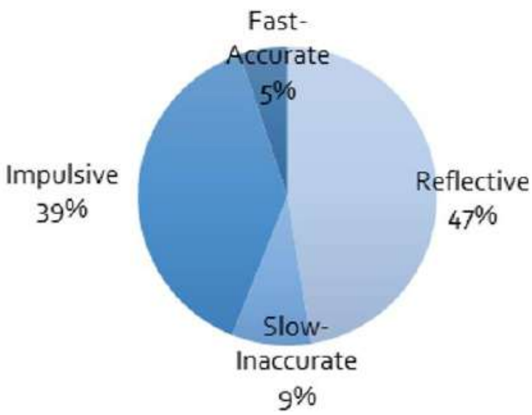


Figure 4. Percentase of Students Base on the Cognitive Styles

by being able to answer well using a long time. Students with a slow-inaccurate cognitive style are characterized by tending to answer incorrectly for a long time. Impulsive students tend to answer incorrectly quickly. And fast-accurate students can answer well in a short time. The results of this study are relevant to Rozencwajg & Corroyer (2005) and (Faradillah et al., 2018) found four students' cognitive styles, namely reflective (slow-accurate), impulsive (fast-inaccurate), fast-accurate, and slow-inaccurate. According to Rozencwajg & Corroyer (2005) and (Seçer et al., 2009) the process of cognition in reflective individuals is able to think analytically with mature cognition. Meanwhile, the impulsive subject in his thinking process is holistic with immature cognition.

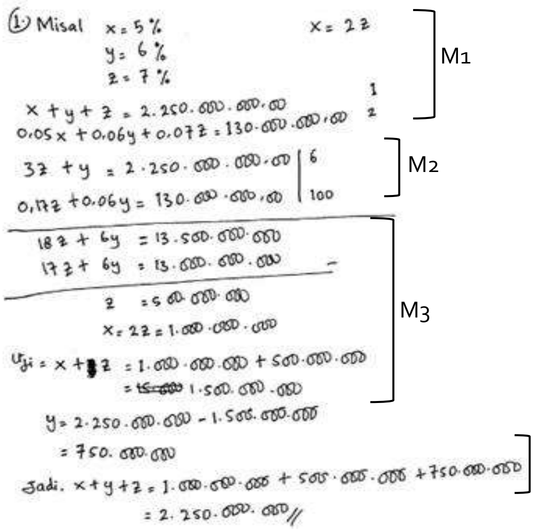
The 11 students with a reflective cognitive style, PN students were selected who had the longest time to take the test and all the answers were correct. Among the 9 students with an impulsive cognitive style, AG students were selected who had the shortest time to do the test with the most answer errors. There are two aspects analyzed in the reflective subject's answers, namely the ability to carry out the stages of problem-solving and problem-solving creativity. The following presentation describes TVLES's problem-solving creativity for subjects with reflective and impulsive cognitive styles.

The Ability of Reflective Subject to Solve TVLES Problems

The following presentation presents the results of the analysis of the ability of subjects who have a reflective cognitive style to solve TVLES problems with the four stages of Polya for problem 1 bank loans and interest rates and problem 2 years of Indonesian historical events.

Problem 1: Bank Loan and Interest Rate

Figure 5 presents the PN subject's answers to problem 1. PN subjects, in lines 1 to 4,



Note: M1 = understanding the problem | M2 = make the plan | M3 = complete the plan | M4 = check the results

Figure 5. The Answer of Subject PN to Problem 1

seem able to write down what is known by assuming the interest rate is x = 5%, y = 6%, z = 7%, and x = 2z, indicating that the PN subject has understood the problem. The results of the analysis of the ability to understand problem 1 in the answers are referred to as the results of interviews with PN subjects.

An excerpt from the interview with the PN subject in Box 1, states that after reading the questions and in his mind Problem 1 can be solved with TVLES. The information obtained is in the form of bank interest on one company's loan. The PN subject succeeded in understanding problem 1, both the facts in the problem and the variable symbolization for these facts.

Box 1: Interview of Understand the Problems 1

After reading the questions, try to explain what you think of problem 1?
"I think the contents of the story problems will be resolved with TVLES."
What is asked in problem 1?
"What was asked in question number 1 was about interest on a loan from a company..."

The PN subject thought when he read the problem that problem 1 could be solved with TVLES and the information was in the form of bank interest on one company's loan. The PN subject succeeded in understanding problem 1, both the facts in the problem and the variable symbolization for these facts.

The answer to the next PN subject is to write down the three-variable equation system model for the mathematical model of the solution. Equation (1) is x + y + z = 2,250,000,000 as the mathematical model for the loan amount. Equation (2) 0.05 x + 0.06 y + 0.07 z = 130,000,000,000 as a mathematical model for loan interest. This answer shows that the PN subject has been able to develop a solution plan by constructing a mathematical model using TVLES. According to the PN subject, the solution is to make equations as presented in the interview excerpts in Box 2.

Box 2. Interview of Make the Plan Problem 1

To work on the problem, what did you do to make your solution easier?
"Determine equation 1, equation 2, and equation 3. As well as other equations if any".

At the completion stage of the mathematical model of the two TVLES problems, the PN subject used two methods, namely substitution, and elimination for the calculations. Equations (1) and (2) are solved by the PN subject at the initial stage by substitution, where the value x = 2z is entered into the system of equations (1) and (2) which results in an equation in the form of a two-variable system of equations to become x + y + z becomes 3z + y, and 0.05x + 0.06y + 0.07z becomes 0.17z + 0.06y. The PN subject succeeded in creating a new, simpler system of equations for equation (1), namely 3z + y = 2,250,000,000, and equation (2) becomes 0.17z + y = 130,000,000.

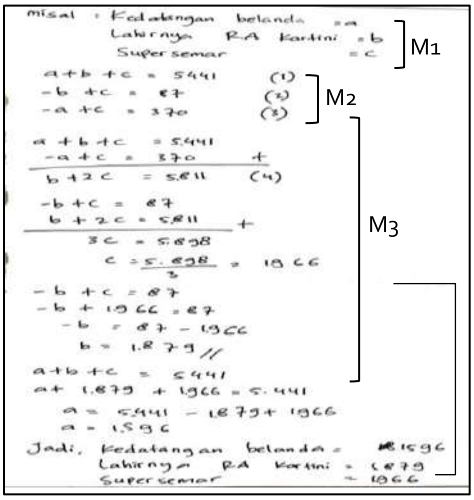
Furthermore, the PN subject solves it by eliminating the coefficients of similar tribe variables on the y variable, to get the values of the z, x, and y variables. The PN subject successfully completed the TVLES calculations for the solution to problem 1 correctly. The PN subject's mathematical reasoning goes well where students can relate the two TVLES solving methods correctly. The results of this study are in line with Setiawan (2016) where reflective subjects can relate mathematical ideas (relate) in solving mathematical problems correctly.

In the final part of solving TVLES, after the x, y, and z values are found, the PN subject checks the solution again, by inserting the x, y, and z values into equation (1), namely x + y + z = 1,000,000,000 + 500,000,000 + 750,000,000 =

2,250,000,000. The results of this calculation indicate that the x, y, and z values from the previous calculations are correct. The results of the analysis of the PN subject's answers are referred to by the results of the interview in Box 3. At this stage, the PN subject was able to check the correctness of the results of solving the problem of bank loans and interest rates. The following is an excerpt of an interview with a PN subject related to checking the results.

> *Box 3. Interview of Check the Solution Problem 1*
>
> Are you sure about the answers you get?
> *"Yes. Because I have proven it by means of the final result, I add it up to prove whether it is correct, whether it is in accordance with the known results."*

Problems 2: Indonesian Historical Events



Note: M1 = understanding the problem | M2 = make the plan | M3 = complete the plan | M4 = check the results

Figure 6. PN Subject's Answer to Problem 2

The PN subject's answer to problem 2 is presented in Figure 6. The PN subject was able to understand the problem by writing, for example, the arrival of the Dutch = a, the birth of R.A. Kartini = b, and Supersemar = c. In the results of the interviews in Box 4 below, the PN subjects have understood what is being asked in problem 2.

> *Box 4. The Interview to Understand the Problem 2.*
>
> Furthermore, what do you know about the information contained in the problem?
> *"What I know about the information contained in the problem is that I can know in what year the Indonesian historical events occurred."*

The PN subject was able to compile a mathematical model into TVLES, where there are three equations that form a true TVLES, namely equation (1) a + b + c = 5441, equation (2) -b + c = 87, and equation (3) -a + c = 370. Then the PN subject checks the results by plugging the values a, b, c into equation (1) in problem 2, namely a + b + c = 5441 ⇨1596 + 1879 + 1966 = 5441. In the results interview in Box 5, the PN subject was able to explain how to check the correctness of his answers, by adding up the values of the variables a, b, c to the equation a + b + c = 5.441.

> *Box 5. Interview of Check the Results Problem 2*
>
> After your results, did you check the results again? Explain!
> *"Yes. I checked it by the way I added it to the example. For example, in the matter of historical events in Indonesia, I assume that a = the arrival of the Dutch, b = the birth of R.A. Kartini, c = Supersemar" namely a + b + c = 5,441.*
> *"I prove it by adding the result of a plus the result of b and then adding the result of c as I get a = 1596, b = 1879, c = 1966. Then add up whether it is true that the result is 5441: a + b + c = 5441 ⇨1596 + 1879 + 1966 = 5441 (so it is proven)".*

Reflective Subject Creativity to Solves the TVLES Problem

Reflective student creativity in solving TVLES problems for problems 1 and 2 at each stage of problem-solving is summarized and presented in Table 7.

Indicators of creativity include fluency, flexibility, originality, and elaboration (Kwon et al., 2006; Marliani, 2015; 2015; Minchekar, 2017; Purnomo et al.,

Table 7. The Analysis of Creativity of Reflective Subject solved the TVLES Problems

Problem-solving skills	Indicators of creativity *Fluency*	*Flexibility*	*Originality*	*Elaboration*
M1: understand the problem	M1-*Fluency*: The idea of symbolizing an example in a variable is true	M1-*Flexibility*: The choice of variable symbol letters in problem 1 and problem 2 is different.	M1-*Originality*: The idea of symbolizing variables according to their own ideas	M1-*Elaboration*: The analogy is determined by the stages of reading, understanding, detailing the facts, writing the example, and elaborating it into the symbolization of the variables x, y, z, and a, b, c
M2: make the plan	M2-Fluency: The mathematical model is written in TVLES form for problem 1 equation 1: $x+ y + z = 2,250,000,000.00$ and equation 2: $0.05x + 0.06y + 0.07z = 130,000,000,000.00$ is true.	M2-Flexibility: Developing a mathematical model adjusting the meaning of the first statement sentence to the second statement sentence in the problem, to form a system of equations to solve the problem.	M2-Originality: The mathematical idea of representing these statement sentences into a mathematical model in the form of a system of equations refers to the meaning of the statement itself and is true.	M2-*Elaboration*: Using the steps to understand the meaning of the question statement sentence and determine the equation that is relevant to the meaning of the sentence.
M3: complete the plan	M3-*Fluency*: The idea with the elimination and substitution method is the correct way of solving TVLES	M3-*Flexibility*: Explaining the solution using the elimination and substitution methods, proceed to check the correctness of the calculation results by entering variable values	M3-*Originality*: Do not appear.	M3-*Elaboration*: Stages of completion of TVLES settlement with detailed steps to find the result of the value of the variable being sought.
M4: check the results	M4-*Fluency*: The way to check the correctness of the answers by entering the variable values obtained from the calculation results into the previous equation is an idea.	M4-*Flexibility*: Do not appear	M4-*Originality*: Do not appear	M4-*Elaboration*: Completion with a detailed elaboration, starting from writing equation (1), substituting the values of the variables x, y, z into equation 1, and completing the calculation so that the sum of the left side of the equatior is equal to the right side of the equation.

2017; Yulianto et al., 2021). The results of the analysis presented indicate that PN subjects with a cognitive-reflective style have the following creativity profile.

Creativity understands the problem. At the stage of understanding the problem of creativity indicators that appear in the PN subject's answers are as follows. *First*, the PN subject uses variable symbolization for the facts in the problem. The idea of symbolizing this variable is an idea that has a true value, which means that the fluency indicator appears. *Second*, PN subjects are also able to make analogies and symbolize variables from one analogy to another. From the example for problem number 1 using the symbols for the variables x, y, and z, to the example for problem 2 using the symbols for the variables a, b, and c. This indicates that the flexibility indicator appears.

Third, the PN subject makes an example by specifying a variable name which is written in detail with the idea of symbolizing the variable from their own idea. In this case, the originality indicator appears. The different symbolization ideas in the two problems indicate that the PN subject has new ideas in variable symbolization. *Fourth*, an example is defined by the stages of reading, understanding, detailing the facts in the problem, then writing it in the form of an example and symbolizing the variables x, y, z, and a, b, c. The stages in this symbolization reflect the presence of an elaboration indicator. Reflective student creativity in solving TVLES problems for problems 1 and 2 at each stage of problem-solving is summarized and presented in Table 7.

The Creativity Make the Plan. PN subjects have ideas regarding solving steps using the elimination method. The mathematical model compiled contains correct ideas regarding fluency, where the mathematical model is written in TVLES form for problem 1 equation 1: x+ y + z = 2,250,000,000.00 and equation 2: 0.05x + 0, 06y + 0.07z = 130,000,000,000.00 is true. Likewise, the mathematical model for solving problem 2 by writing equation 1: a + b + c = 5441, equation 2: -b + c = 87, and equation 3: -a + c = 370 is true.

The idea of compiling a mathematical model is drawn from the meaning of the statement sentences in problems 1 and 2 which are understood to determine the coefficients and variable names in problem 1 for equation 1. Based on this meaning, write the operation sign (+) for the variables x, y, and z that make up equation 1. Then move again to the second statement in problem 1, where the coefficients of the variables x, y, and z are determined based on the bank's interest rate and use the addition operation sign (+) to represent equation 2.

The PN subject also does the same in solving problem 2. In this case, the PN has the flexibility of thinking in making a mathematical model of the solution to problem 1 and problem 2. The mathematical model is formulated based on the meaning understood by the PN subject to the statement sentences in problems 1 and 2. Where the mathematical idea to represent the statement sentences in a mathematical model is true. The mathematical model contains indicators of novelty (originality) and uses steps from understanding the meaning of the question statement sentences and determining their equations (elaboration).

The Creativity Completes the Plan. The description of calculations to find the values of x, y, z, or a, b, c made earlier contains the correct ideas (fluency). PN subjects are fluent in solving equation models by elimination and substitution. The completion stage of TVLES with substitution followed by elimination indicates that the translation is prepared to move from one correct way to another (flexibility). Another characteristic seen in the stages of completing the TVLES model for solving problems 1 and 2 is the detailed steps to find the result of the value of the variable being sought. In other words, the TVLES completion stage for solutions to problems 1 and 2 has elaboration characteristics.

The Creativity to Checks Back the Solution. PN subject was able to re-check the solution to problems 1 and 2. Re-examine the solution to ensure that the method was correct and fluent. Stages of completion with a detailed elaboration, starting from writing equation (1), substituting the values of the variables x, y, and z into equation (1), and completing the calculations. So that the sum of the left side of the equation is the same as the right side of the equation. Thus, it can be stated that the PN subject's ability to examine the results has creativity with elaboration indicators.

The Ability of Impulsive Subject to Solve TVLES Problems

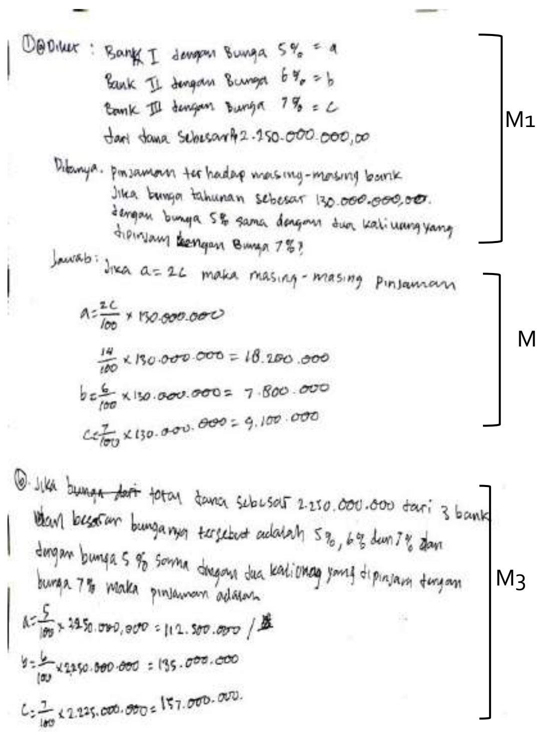
Subject AG has an impulsive cognitive style that answers in the shortest time with the least number of correct answers. The following presents the results of the analysis of the AG subject's ability to solve problems 1 and 2.

Problems 1: Bank Loans and Interest Rates

AG subjects were able to understand loan problems and bank interest rates, by writing down what was known and what was asked. AG writes down what is known by making an example in the form of variables a, b, and c for each of the bank interest rates and loan funds from problem 1. What is asked by rewriting the question sentence from problem 1? Figure 5 presents subject AG's answer to problem 1.

Subject AG developed a solution plan using the concept of comparison to determine a mathematical model. The mathematical model that was created did not match the mathematical concepts in problem 1, where subject AG used comparisons while the mathematical concepts in problem 1 used TVLES. Subject AG was unable to construct a correct mathematical model for problem 1 solutions.

Subject AG developed a solution plan using the concept of comparison to determine a mathematical model. The mathematical model does not match the mathematical concept in problem 1, where subject AG uses the concept of comparison, which is correct using the concept of TVLES. Subject AG was unable to construct the correct mathematical model for problem 1 solutions. Because the completion of the mathematical model was not in accordance with the stages of solving



Note: M1 = understanding the problem | M2 = make the plan | M3 = complete the plan | M4 = check the results

Figure 7. Subject AG's Answer to Problem 1

TVLES, as a result, an error occurred at the stages of completion and obtaining the result.

> *Box 6. The Interview to Understand the Problem 1*
>
> After reading the questions, try to explain what you think about the concept of the problem.
> *"By way of example, changing into a linear equation then using the elimination method after that the substitution method to get the value or loan from each bank"*
> What do you know about the information contained in the question?
> *"The company borrowed IDR 2,250,000,000.00 from three banks with the interest of 5%, 6%, and 7% respectively for a total interest of IDR 130,000,000,000.00."*
> What is being asked in this question?
> "Company loans to each bank?"

The results of interviews with AG subjects are presented in Box 6. After being interviewed, subject AG gave an answer that was different from the written answer. At the stage of understanding the problem, subject AG stated that by changing the example to obtain a linear equation then using the elimination and substitution methods.

At the stage of making a mathematical model, the subject AG makes a mathematical model with only one linear equation, which should be formulated by three linear equations. But when interviewed, the subject AG gave an inconsistent answer with a written answer in Box 7. The following presents an interview trailer with the subject AG.

> *Box 7. The Interview to Make a Mathematical Model*
>
> What are the concepts used for solving the problem from the information obtained in the problem?
> *"After being formed, the equation will be obtained:*
> *a + b + c = 2,250,000,000.00*
> *2C + B + C = 2,250,000,000.00*
> *3C + B = 2,250,000,000.00 ... (1). And*
> *5% A + 6% B + 7% C = 130,000,000.00*
> *17% C + 6% B = 130,000,000.00*

At the stage of completing the plan, in the answer sheet due to the stage of making the model being wrong, the continuation at this stage the subject AG also makes a mistake in making calculations. The interview trailer of Box 8 showed the inconsistency of AG in providing answers.

The results of the interview with the subject AG showed that he was able to complete the mathematics model solution of problem 1 using the elimination and substitution methods correctly. The subject AG realized that the answer was written in the wrong answer sheet. And after interviewing the subject AG was able to improve the answer. AG subjects can describe their calculations with the method of elimination and substitution correctly.

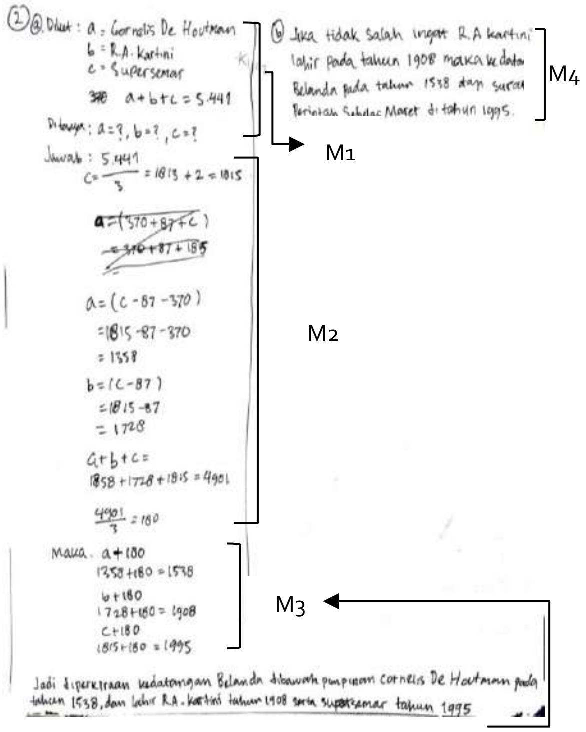
> *Box 8. The Interview of Complete the Plans*
>
> How do you make a mathematical model and its solution to the problem?
> *"Build the equation of*
> *3c + b = 2.250.000.000 ... (1)*
> *17c + b = 13.000.000.000..(2)".*
> What is the solution you provide to solving the problem?
> *"Elimination method:*
> *3c + b = 2.250.000.000.000 |×6| 18c + 6b = 13.500.000.000*
> *17c + b = 13.000.000.000 |×1| 17c + 6b = 13.000.000.000*
> *-*
> *c = 500.000.000"*
> *"substitution method:*
> *c = 500.000.000*
> *3c + b = 2.250.000.000*
> *3(500.000.000) + b = 2.250.000.000*
> *1.500.000.000 + b = 2.250.000.000*
> *b = 750.000.000*
> *a = 2c*
> *a = 2(500.000.000)*
> *a = 1.000.000.000".*

The interview treasure of check solution with the subject AG is presented in Box 9. In the final stage, checking the results conducted an interview with the subject of AG regarding the answer written in the answer sheet. The AG subject does not link the answer examination on the answer sheet that has been done but checks the results based on the answers submitted in the interview.

> *Box 9. The Interview to Check the Solution*
>
> What are you checking? Try to explain!
> *"Yes, throughout substitute the values of variables to the equations:*
> *a = 500.000.000*
> *b = 750.000.000*
> *c = 1.000.000.000*
> *a + b + c = 2.250.000.000*
> *(500.000.000) + (750.000.000) + (1.000.000.000) = 2.250.000.000*
> *⇨ 2.250.000.000 = 2.250.000.000."*

Problems 2: Indonesian Historical Events

The AG subject is also able to understand problem 2 by giving a visitation for the year for three historical events in Indonesia, and by giving a symbol of variables A, B, and c. The subject AG is also able to make a mathematical model A + B + C = 5,441, but incomplete, where there is only one algebraic equation written. There should still be two more equations written, namely -b + c = 87 and -a + c = 370. The subject of subject for problem 2 is presented in Figure 8.



Note: M1 = understanding the problem | M2 = make the plan | M3 = complete the plan | M4 = check the results

Figure 8. The Answers of Subject AG to Problem 2

The answers given by the AG subject in the answer sheet referred to the results of interviews related to problem-solving stage 2, showing inconsistency in solving problem 2. The interview trailer in Box 10 shows that answers were written with different interview results.

Box 10. The Interview Treasure to Make Mathematical Models

What was the first to do to make a mathematical model and its solution to the problem?

"Build the equations:
y = z – 87 .... (1)
x = z -370 .... (2)."

What is the elaboration of the solution?

"Substitute:
x+ y + z = 5441
(z – 370) + (z – 87) + z = 5441
3z – 457 = 5441
3z = 5441 – 457
3z = 3898
z = 1966

for z = 1966	*x = z - 370*
y = z – 87	*x = 1966 -370*
y = 1966 – 87	*x = 1596*
y = 1879".	

Is there another solution? Explain!

"There is, when studying the year of the events, or one of them, for example, the year of Supersemar's birth in 1966, put in the equation:

y = z – 87	*x = z - 370*
y = 1966 – 87	*x = 1966 - 370*
y = 1879	*x = 1596".*

The results of the settlement made by the subject AG are in the answer sheet by guessing. In contrast to the AG subject's answer in the interview in Box 11, able to check the results correctly.

Box 11. The Interview to Check the Solution

What are you checking? Try to explain!

"Yes, by entering the variable value into the equation:
x = 1596
y = 1879
z = 1966
x + y + z = 5441
1596 + 1879 + 1966 = 5441
5441 = 5441."

The Creativity of Impulsive Subject solving the TVLES Problems

AG subjects quickly answered, a short time in writing answers during the test with a quick time for both problems, but the answers are wrong. But when interviewed by the subject AG confirmed the correct answer and realized his mistake after the answers were collected. The subject AG is not careful in reading and understanding the sentences in problems 1 and 2, so he only writes down the equation a + b + c = 5441.

The results of the analysis of the ability to understand problems 1 and 2 in the answers given by the subject AG refer to the answers written on the answer sheet. Because the answer pattern written on the answer sheet is the first answer, given. In understanding problems 1 and 2, the subject AG writes what is known and what is asked correctly, with the visitation of variables according to their own ideas. The subject of AG has a true idea related to the visitation of the variable, the element of fluency appears and contains a new idea in its own way (originality) appears in the AG subject's answer.

But at the stages of the next problem solving, namely preparing plans, carrying out solutions, and checking out results, in the answers of the subject AG does not appear all four characteristics of creativity. Because the mathematical model is arranged, and the solution is wrong.

The prominent feature of the impulsive subject in solving the TVLES problem is the inconsistency of the answers written with the answers given when interviewed. The answers written use different methods in the way mentioned in the interview. When answering the questions in the answer sheet, the impulsive subject thinks about the answer by reading sentences in problems 1 and 2 and immediately writes the answer, without looking back at the contents of the problem. The mistake of answering was only realized by the reflective subject after a few days and was delivered in the interview.

Figure 8 presents the results of the analysis of the creativity of the subject of AG solving problems 1 and 2. The prominent feature of the impulsive subject in solving the TVLES problem is the inconsistency of the answers written with the answers given when interviewed. The answers written use different methods in the way mentioned in the interview. When answering the questions in the answer sheet, the impulsive subject thinks about the answer by reading sentences in problems 1 and 2 and immediately writes the answer, without looking back at the contents of the problem. Resulting in errors in the answer. The mistake of answering was only realized by the reflective subject after a few days and was delivered in the interview.

Discussion

The study aims to describe the ability of students' creative thinking in solving TVLES problems in terms of reflective and impulsive cognitive styles. TVLES issues related to the theme of bank loans and bank interest and years of historical events in Indonesia. The results of the data analysis show that reflective student was able to solve the problem of bank loans and the years of historical events in Indonesia correctly. Meanwhile, the impulsive student makes some mistake solution of that problems.

The advantages of this study lie in the form of non-routine TVLES problems, requiring a high level of thinking ability in their resolution. Analysis of creativity in solving problems is focused on students. The results of previous research on the type of problem and creativity-solving problems discuss more solutions to mathematical problems in schools. While the problem in this study is focused on mathematical material for prospective mathematics teachers. Based on the cognitive style, the results of previous research use the creator of learning styles of field-dependent and independent fields. This study specifically analyzes student creativity in solving problems according to the cognitive style of reflection and impulsiveness.

The stages of understanding the problem, compiling a mathematical model, completing the mathematical model, and checking out the results correctly. Students can determine the number of loans in three banks with different interest rates and are able to determine the year of historical events in Indonesia using Mathematics models related to TVLES. Reflective students also have consistency in solving problems but require a long time to answer.

Research findings from the results of the analysis of the ability to solve TVLES problems reflective and impulsive students are as follows. *First*, reflective students can solve TVLES problems using Polya's problem-solving stage correctly. *Second*, reflective students have consistent problem-solving answers, made for a long time, but the answer is correct.

Third, the cognitive control of reflective students looks better, where students can re-check the truth of the final answer carefully. Unlike the findings of Lahinda & Jailani (2015), who found that in junior high school students, reflective subjects tend to have low cognitive control compared to impulsive subjects. Mubarika et al. (2022) state that creativity also affects self-regulation in learning mathematics.

Fourth, students with impulsive cognitive styles can understand TVLES problems. But not able to compile and complete the mathematical model correctly, as well as at the stage of checking out the results. Mathematical model and the settlement stage is incorrect logically. *Fifth*, impulsive students quickly write answers but are not careful in understanding the meaning of sentences in the problem mentioned above. So impulsive students are not able to solve problems at the next stage. Impulsive students only realized their mistakes after some time and were able to correct their answers correctly, which was seen in the interview results.

Students with impulsive cognitive styles can solve the problem of bank loans and bank interest and years of historical events in Indonesia, at the stage of understanding problems. But not able to compile and complete the mathematical model correctly, as well as at the stage of checking out the results. The answers given by impulsive students are wrong, whereas the mathematical model and the completion stage are wrong.

Impulsive students are fast in writing answers but are not careful in understanding the meaning of the sentence in the problem mentioned above. This finding was strengthened by Fadiana (2016), who found that impulsive students tend to solve mathematical story problems faster than reflective students. It can be concluded that reflective students have a better TVLES problem-solving ability than impulsive students. According to Silma et al., (2019), impulsive subjects answered questions quickly and were not examined again, tend to dislike analogy problems, often answer wrong, had poor problem-solving strategies, and gave inaccurate opinions. The mathematical model that is arranged also cannot be justified in mathematical logic.

Students with impulsive cognitive styles are only aware of their mistakes after some time and can correct the answers correctly. Characteristics of impulsive subjects answer questions quickly, tend to dislike analogy problems, often answer wrong, have poor problem-solving strategies, and providing inaccurate opinions. The findings of this research are supported by Chen (2021) that the reflective subject has the ability to speak English better than impulsive subjects. From the results of the analyses, it can be stated that students with reflective cognitive styles have better thinking control, compile answers carefully and thoroughly, capable.

Implications

The characteristics of the reflective and impulsive cognitive style affect creativity in solving TVLES problems. The characteristics of this cognitive style need to be considered in learning. It would be very effective for learning to be carried out by giving different treatments to reflective and impulsive subjects. The implication for lecturers in designing and implementing learning refers to an approach in differentiation learning throughout profiling to find the cognitive style of their students.

If learning is carried out using individual methods, reflective students are given TVLES learning assignments by providing sufficient time allocation, occasionally giving metacognitive questions, and giving them the opportunity to think about finding solutions longer.

Whereas for students with an impulsive cognitive style, individually, giving TVLES learning assignments can start from the easy ones and gradually move up to the difficult ones. Impulsive students need to practice reading and understanding the material more thoroughly. Lecturers guide students by giving metacognition questions repeatedly. Even, if necessary, impulsive students are given individual remedial/consulting programs for completing TVLES assignments. The aim is to provide an opportunity for impulsive students to re-examine the mistakes made in completing the TVLES problem-solving task.

If learning is carried out using a method that demands group collaboration, the lecturer needs to consider the diversity of cognitive style characteristics in forming assignment groups. Reflective and impulsive students can be combined in one group. Where reflective students with a high level of accuracy can become peer tutors for impulsive students. So that there is a process of dividing the tasks and obligations of everyone in group cooperation.

CONCLUSION

Reflective students can solve TVLES problems correctly, thoroughly, and consistently with their answers. Meanwhile, impulsive students make many mistakes in the four stages of problem-solving and tend to make solutions inconsistent.

Students with a reflective cognitive style have creativity in solving TVLES problems at the stage of understanding the problem and constructing a mathematical model with the characteristics of fluency, flexibility, novelty, and elaboration. At the stage of completing the TVLES model, creativity emerges with the characteristics of fluency, flexibility, and elaboration. At the stage of examining the results, creativity appears with the characteristics of fluency and elaboration.

Students who have an impulsive cognitive style at the stage of understanding the problem have creativity with fluency, novelty, and elaboration characteristics. In the stages of problem-solving, creating a mathematical model, completing a mathematical model, and checking the results, because the fluency aspect does not appear, the four characteristics of creativity at this stage do not appear.

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The Effect of Problem-Based Learning Assisted by Video Animation on Students' Self-Efficacy and Creative Thinking Ability

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Abstract

Students' creative thinking skills and different self-efficacy cause weaknesses for students in solving problems presented in learning mathematics. This study aimed to determine how implementing video-assisted problem-based learning affects students' self-efficacy and creative thinking abilities. This research method uses quantitative with a quasi-experimental research design. The study sample population of class XII IPA 2 students consisted of 34 students in the experimental class and 30 students in the class XII IPA 1 and control classes. Statistical analysis of N-Gain score of self-efficacy sig 0,014 < 0,05 and creative thinking skills sig = 0,003 < 0,05. The study results show significant differences in self-efficacy and creative thinking skills of students in the experimental class compared to the control class. This indicates the enormous difference in gains between experimental and control classes. Thus, the influence of problem-based learning assisted by video animation on students' self-efficacy and creative thinking abilities is very large. Problem-based learning model with animated videos can organize students in informing learning objectives so that students have the motivation to be actively involved in problem-solving activities.

Keywords: *Ability Creative Thinking; Animation Videos; Self-Efficacy*

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Abstrak

Kemampuan berpikir kreatif siswa dan self eficacy yang berbeda menyebabkan kelemahan bagi siswa untuk memecahkan masalah yang disajikan dalam pembelajaran Matematika. Tujuan dari penelitian ini adalah untuk mengetahui pengaruh penerapan pembelajaran berbasis masalah berbantuan video animasi terhadap kemampuan efikasi diri dan berpikir kreatif siswa. Metode penelitian ini menggunakan kuantitatif dengan desain penelitian quasi experiment. Sampel penelitian ini adalah siswa kelas XII IPA 2 terdiri dari 34 siswa sebagai kelas eksperimen dan siswa kelas XII IPA 1 terdiri 30 siswa sebagai kelas pembanding. Analisis statistik tes berpikir kreatif memperoleh nilai signifikasi = 0,003 < 0,05 and efikasi diri sebesar 0,014 < 0,05. Hasil penelitian menunjukkan perbedaan yang signifikan antara berpikir kreatif dan efikasi diri siswa pada kelas eksperimen dan kelas kontrol. Dengan demikian bahwa pengaruh penerapan pembelajaran berbasis masalah berbantuan video animasi terhadap efikasi diri dan kemampuan berpikir kreatif siswa sangat besar. Model pembelajaran berbasis masalah dengan video animasi dapat mengorganisasikan siswa dalam menginformasikan tujuan pembelajaran sehingga siswa memiliki motivasi untuk terlibat aktif dalam kegiatan pemecahan masalah.

INTRODUCTION

21st-century education can integrate knowledge (Blaique et al., 2022; Kim et al., 2019), skills (Laar et al., 2017), attitudes (Ghani et al., 2020; Hussin et al., 2019), and mastery of Information and Communication Technology (ICT) to prepare quality Human Resources (HR) in facing global challenges (Peters-burton & Stehle, 2019). Improving the quality of human resources, both hard skills and soft skills, must be balanced with improving the quality of education (Yuniendel, 2018). Improving the quality of education can be realized through learning directed at helping students master specific abilities to achieve the expected goals. 21st-century students are required to be able to master science (Aslamiah et al., 2021), have metacognitive skills (Karatas & Arpaci, 2021), be able to think critically and creatively (Darmayanti et al., 2022), and be able to communicate and collaborate well.

The cap potential to suppose creatively, also called the ability to think at a higher level is one of the goals of the 2013 syllabus and must be achieved by students, including in Mathematics (Mercier & Lubart, 2021). Students must have creative thinking skills to express ideas and solve problems (Durmuşoğlu et al., 2021). The ability to think creatively is a thought process to express new ideas, see things from new perspectives, and form new combinations of two or more previously learned concepts to solve a problem from a different perspective.

The problem of the low ability of children's creative thinking is due to the learning model, which is still teacher-centered, using the lecture method (Masfingatin et al., 2020; Novianto et al., 2020), so students tend to be passive in learning. This causes a lack of trust and confidence in students. Students tend not to be confident in giving opinions and lack confidence in answers to questions given by the teacher.

MAN 2 Malang City is one of the madrasas continuing to innovate in teaching and learning activities as a response to educational developments. Learning media has been used in almost all teaching and learning activities in each subject. However, problems still arise, namely the ability to think creatively and students' self-efficacy. Based on the pretest results in students' mathematics learning, it was found that the problem was that students' creativity in working on math problems was still lacking, as in Figure 1.

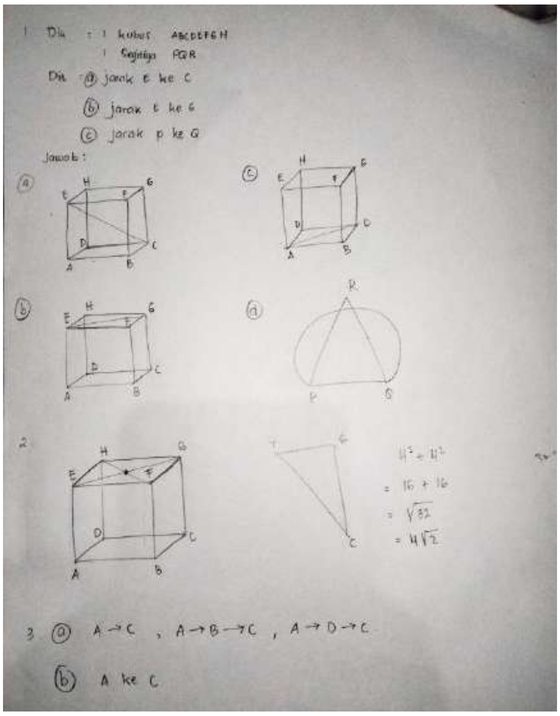

Figure 1. Students' Pre-test Results

In addition to self-efficacy, most students are still less active and less confident in expressing their opinions in mathematics. When interviewed, the teacher gave a quiz. Some students stated that they had done it but did not want to voluntarily present the results of their work because they were unsure of the answers and sometimes even saw their friends' work.

The students' activity problem in learning and confidence in solving math problems and conveying ideas is a problem in the cognitive domain. The attitude domain must also be considered to support student success in learning mathematics. Self-efficacy must be considered (Alqurashi, 2016). (Bandura, 1997) self-efficacy affects how a person thinks, feels, motivates, and acts. Students with high self-efficacy tend to make more significant efforts to achieve learning achievement. Students who are not confident in their abilities will hinder their learning process. When given an assignment, they will experience problems when completing it and when given the opportunity to express their opinion, they hesitate to express their opinion. Students who have high self-confidence can think creatively and believe that they are able to solve the problems they face.

Efforts to increase the self-efficacy and creative thinking abilities of students who master skills in mathematics can be made by improving the learning process. Interactive, learning mathematics with fun helps improve students' creative thinking and mathematical self-efficacy. One applicable learning model is problem-based learning, but the use of learning models alone is insufficient and not optimal, so learning media needed that help students and can support the implementation of Problem-Based Learning (PBL).

The benefits of PBL in developing mathematical creative thinking skills are supported by previous research (Dewi & Harjono, 2021), showing that the PBL model is more effective in increasing mathematical creative thinking skills than the Problem Solving (PS) model. Research has shown that applying problem-based learning methods can improve students' creative and creative thinking skills; consistent with the research (Maskur et al., 2020), the PBL model can influence mathematical creative thinking abilities using an open-ended approach.

The importance of self-efficacy in learning is supported by previous research (Farochmah & Leonard, 2021), showing a positive effect of self-efficacy on mathematics learning in intermediate-level students. Research conducted by (Rangkuti et al., 2021) shows a significant positive effect of self-efficacy on mathematics learning outcomes. Meanwhile, research (Adha & Rahaju, 2020) states that self-efficacy influences students' learning outcomes in mathematics.

Research on the impact of problem-based learning with video animation on students' creative thinking abilities and self-efficacy has not been found. Research (Dewi & Harjono, 2021; Maskur et al., 2020) examines the application of PBL to mathematical creative thinking skills, while (Kardoyo et al., 2020) examines the application of PBL to creative and creative thinking abilities. As for research on the application of PBL associated with student self-efficacy, it has been carried out by (Ernawati, 2020; Sariningsih & Purwasih, 2017; Sujarwo, 2020; Wiratmaja et al., 2014) stated that problem-based learning can increase student self-efficacy. At the same time, research on the application of PBL assisted by learning media (question cards) has been carried out by (Ratnawati et al., 2020). This states that problem-based learning is more effective when supported by instructional media designed to help students understand the material. Research conducted by (Aminy et al., 2021) revealed that students' mathematical creative thinking increased with a problem-based learning model based on Geogebra. However, in research (Aminy et al., 2021), GeoGebra can only be applied to certain materials. Therefore, the research chosen chooses animated videos that can be applied to all mathematics material by combining variables in previous research, namely Problem-Based learning, creative thinking skills, and student self-efficacy as a differentiator from previous research. So research on the Effect of Problem-Based Learning assisted by animated videos on students' self-efficacy and creative thinking abilities is essential to research.

Therefore, two formulation problems will be analyzed: students' self-efficacy and creative thinking abilities in applying video-assisted problem-based learning outperform students taught by traditional methods.

METHODS

Quantitative research is used in this study with the Quasi Experiment *method* (Pseudo-Experiment). The population in this study were students of class XII MAN 2 Malang City. The population selection was based on the reason that the students' mathematics year-end assessment (PAT) scores at school were still low. This can be seen from the 2021/2022 school year results. A non-equivalent control group design was used in this study. Therefore, two classes were sampled. Class XII IPA 2 with a total of 34 students as an experimental class taught by video-assisted PBL, and class XII IPA 1 with 30 students in the character of control class taught by conventional and typical methods. The researcher selected two classes randomly using a targeted random sampling technique. In this study, the independent variable was video-assisted PBL, while self-efficacy and creative thinking ability were the dependent variables. The learning process lasted for three meetings. Data was collected from the pre-test and post-test results of students' self-efficacy and creative thinking abilities.

Self-efficacy data was collected from a questionnaire consisting of 20 questions adopted from Rangkuti et al., (2021). There are three dimensions, namely (a) level dimension, (b) *strength*, and (c) *generality*—a questionnaire with 20 questions consisting of 12 positive questions and 8 negative questions. Tests for students' creative thinking abilities related to three-dimensional material in compulsory mathematics for class XII SMA/MA consist of 3 essay questions adapted from (Qomariyah & Darmayanti, 2023), which has a valid value with high criteria for all questions and a reliability value of 0.743. The preparation of these questions is adjusted to indicators of creative thinking skills adapted. Indicators of the ability to think creatively are (a) fluency, (b) Elaboration, (c) Flexibility, and (d) Originality.

Descriptive statistics and inferential statistics are data analysis techniques used in this study. Descriptive analysis of the pre-test and post-test data begins with the relative frequency distribution and then uses descriptive statistical tables. The relative frequency distribution of the creative thinking data is used to find the difference between the post-test and pre-test percentage scores. Thus, the significant improvement percentage of the progress can be noticed. The self-efficacy data is used to check the effect of self-efficacy when learning mathematics. The phase of inference statistical analysis of pre-test data begins with tests for normality, uniformity, and average similarity. The following inferential statistical analysis for confirming increases using N-gain data begins with N-gain difference tests analysis, N-gain value criterion tests, and effect size tests.

An analysis of the N-gain effect size test was used to see how significant the differences in the effects of self-efficacy and creative thinking skills were between the two classes. The formula that can be applied for the effect size of test criteria and the effect size is shown below:

$$d = \frac{< g >_{sbl} - < g >_r}{< SD >}$$

To calculate using the formula above, the author provides some information related to the terms and symbols in question. This information is like the symbol d (to indicate the effect size), then for $<g>_{sbl}$ is the average value of N-gain in the experimental class. Furthermore, $<g>_r$ is used for the average N-gain value in the control class, and the last symbol $<SD>$ is the average value of the standard deviation.

Table 1. Criteria for the effect size tests

Effect Size	size	Interpretation
d ~0.80	Large	dominant
d ~0.50	Medium	Less dominant
d ~0.20	Small	Not dominant

Note. d = effect size value, adapted from "Plain and Simple Statistics" by Sherri L. Jackson, 2014.

An analysis of the criteria for the N-gain score was conducted to determine how effective PBL assisted by video animation is used for self-efficacy and creative thinking skills. The table below shows the formulas for determining the N-Reinforcement value and N-Reinforcement score criteria:

$$N - gain = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score}$$

Table 2. Normalized Gain value criteria

N-gain Score	Size	Interpretation
$g \geq 0.7$	High Point	Very Efficient
$0.3 \leq g < 0.7$	Moderate	Efficient
$g < 0.3$	Low Point	Less Efficient

Note: g = normalized gain-value, adapted from "Analyzing Change/Gain Score" by Richard R. Hake, 1997.-

Researchers have tried to adjust the experimental and control classes, but although the two groups have relatively similar mean pre-test scores, there are still weaknesses. Researchers cannot form classes by taking random samples from parallel classes because it interferes with the class.

Table 3. Relative Frequency Distribution of Creative Thinking

Indicator Creative Thinking	Control				Experiment			
	Pre-test		Postest		Pre-test		Postest	
	Less Optimal	good	Less Optimal	good	Less Op timalll	good	Less Optimal	good
Fluency	80%	20%	60%	40%	70%	30%	60%	40%
Elaboration	75%	25%	65%	35%	70%	30%	62%	38%
Flexibility	78%	22%	70%	30%	72%	28%	70%	30%
Originality	86%	14%	80%	20%	82%	18%	76%	34%

Researchers also do not allow control over student circumstances outside of research. For example, students may not attend math classes outside their scheduled classes. Interaction with other teachers, groups of mathematics classes outside of school hours, tutoring, etc., may affect the learning outcomes they achieve. In terms of analysis, quantitative methods are analyzed with inferential statistics, i.e., average or overall analysis, making it challenging to observe deeper states and signs. The researcher intends to explain the actual situation and condition through descriptive statistics. However, the researcher still could not explain the situation representing the sample individually and as a whole.

RESULTS AND DISCUSSION

Results

Creative Thinking Ability

Table 3 shows the relative frequency percentage of each class and metric data collection. The control class increased the fluency index of teaching by 20%, the sophistication index by 10%, and the flexibility index by 8%. The uniqueness index increased by 4%. The experimental class increased the fluency index of teaching by 10%, the elaboration index by 8%, and the flexibility index by 2%. 16% increase in originality index. It can be seen that the percentage of improvement in creative thinking ability in the experimental class taught with *Problem-Based Learning* assisted by animated videos is greater than that of the control class. It shows that the creative thinking ability of students taught with Problem-Based Learning assisted by animated videos is better than those taught conventionally.

Data on pre-test scores for creative thinking abilities analyzed using descriptive statistics showed that the two classes had almost the same or not many different averages and variances. In contrast, in the post-test data, after being taught with Problem-Based Learning assisted by animated videos, the experimental class experienced an average increase. The average ability to think creatively is higher than the control class. The results are shown in Table 4.

Table 4. Descriptive Statistical Analysis

	Pre-test		
	N	Means	SD
Control	30	63,21	1,533
Experiment	34	63.95	1,419
	Post-test		
	N	Means	SD
Control	30	70,84	1,947
Experiment	34	78,37	1,844

The gains in creative thinking skills obtained based on the descriptive statistics described above should be analyzed further by performing statistical tests to determine differences in significant improvements. Normality testing of pretest data was performed using the Shapiro-Wilk statistical test. The control class statistic was sig 0.993 > 0.05, and the experimental class statistic was 0.941, so H_0 is accepted. From this, we can conclude

Table 5. Relative Frequency Distribution of *Self-Efficacy*

Self-efficacy Indicator	Control				Experiment			
	Pre-test		Postest		Pre-test		Postest	
	Less Optimal	good	Less Optimal	good	Less Optimal	good	Less Optimal	good
Levels	73%	27%	61%	39%	68%	32%	61%	39%
strength	76%	24%	65%	35%	70%	30%	61%	39%
generality	77%	23%	72%	28%	71%	29%	68%	32%

that the pre-test data are normally distributed. The Levene Statistic test is the statistical test used to test the homogeneity of the pre-test data. The significance *Levene* Statistic value for the pre-test is 0.377 > 0.05, and for the post-test, 0.740 > 0.05; the value of the two variants of the data are homogeneous.

Mean similarity tests were analyzed using statistical t-tests for pre-test sig = 0.988 and post-test sig = 0.002 for identical variants. There is no significant difference in creative thinking ability before receiving treatment and increasing after teaching Problem-Based Learning assisted by animated videos between students in the experimental and control classes.

The analyzed N-gain (normalized gain) mathematical creative thinking skills data was sig = 0.003 < 0.005, which rejects Ho. This demonstrates that the creative thinking skills taught by students using a problem-based learning model supported by video animation have improved significantly and outperformed traditional students.

Self-Efficacy in Mathematics Learning

Post-test data shown in table 5, mathematics learning self-efficacy trends in the control class did not outperform the experimental class taught with problem-based learning using video animation. The percentage difference in learned self-efficacy before and after the mathematics test. The control class is smaller than that in the experimental class, and there is a percentage increase in the self-efficacy frequency after the test. Learning in mathematics learning is after application to two different classes.

This indicates that students in practical classes taught problem-based learning are more likely to learn mathematics self-efficacy than traditional methods. Pre-test data from descriptive analyzes of learning self-efficacy in mathematics questionnaires for both grades had similar or little difference in mean and variance, whereas post-test data showed average student self-efficacy. Mathematics learning differs between the two classes, as shown in Table 6.

Table 6. Descriptive Statistical Analysis

	Pre-test		
	N	Means	SD
Control	30	53,21	1,955
Experiment	34	56.95	1,957
	Post-test		
	N	Means	SD
Control	30	60,84	1,857
Experiment	34	68.97	1,486

Additionally, an inference statistical data analysis is performed, and the self-efficacy learning mathematics pretest data are analyzed with nonparametric statistics as they are on an ordinal scale beginning from the mean similarity of the pre-test data.

The gains in self-efficacy obtained based on the descriptive statistics described above should be analyzed further by performing statistical tests to determine differences in significant improvements. Normality testing of pre-test data was performed using the Shapiro-Wilk statistical test. The control class statistic was significance = 0.106 > 0.05, and the experimental class statistic was 0.160 with significance = 0.095 > 0. 05, so H_0 is accepted. From this, we can conclude that the pre-test data are normally distributed. The Levene Statistic test is the statistical test used to test the homogeneity of the pre-test data. The significance Levene Statistic value for the pre-test is 0,509 > 0.05, and for post-tes, 0.085 > 0.05, which means the value of two variants of the data are homogeneous.

Mean similarity tests were analyzed using statistical t-tests for pre-test sig = 0.795 and post-test sig = 0.001 for identical variants. There is no significant difference in self-efficacy before receiving treatment and increasing after teaching Problem-Based Learning assisted by animated videos between students in the experimental and control classes.

The N-gain (normalized gain) self-efficacy data analyzed was sig = 0.014 < 0.005, which rejects Ho. This demonstrates that the students' self-efficacy using the problem-based learning model supported by video animation has improved significantly and outperformed traditional students.

Discussion

Findings Statistically Analyzed Show Influence Students' Creative Thinking Skills and Self-Efficacy Conferred by Video-Assisted Animation Problem-Based Learning Models. These two variables have a significant influence. The effectiveness of the problem-based learning model assisted by video animation is moderate for each variable.

In the group of students who applied problem-based learning assisted by video animation, there was a significant increase in creative thinking skills, which was better than in the group of students who applied conventional learning. So, there is a significant difference in the increase in the ability to think creatively between the experimental and control classes due to the application of the learning model. Problem-based learning assisted by animated videos is more effective and influences creative thinking skills than conventional learning models. Similarly, for the self-efficacy learning variable, students taught with a problem-based learning method using video animation showed increased self-efficacy learning compared to those taught with a conventional method. A significant difference is seen in, obtained, a significant difference in influence between the two classes. The problem-based learning model assisted by video animation is more influential in self-efficacy learning than conventional learning models.

Increase self-efficacy and creative thinking with an anime video assisted-problem-based learning model. At each stage of an animated video-assisted problem-based learning model, students must complete complex tasks, possess strong beliefs, and be able to perform a variety of tasks simultaneously. Applying this model allows students to think fluently, sophisticatedly, flexibly, and originally.

In the first stage, organizing students on problems, teachers inform learning goals, explain necessary logistical requirements, and motivate students to participate in problem-solving activities (Almulla, 2020; Arnidha & Fatahillah, 2021; Maxwell, 2020; Prayogi & Asy'ari, 2013; Zhao et al., 2020). In this case, the teacher's importance of self-motivated self-efficacy can increase students' confidence in completing complex tasks (Semilarski et al., 2021). Also, describing logistical needs requires thinking creatively about the elaboration indicator in detail and the information provided

(Kardoyo et al., 2020; Rudibyani, 2019; Rusijono et al., 2020; Wicahyono et al., 2018). Not only that, in organizing problems, students are expected to be able to formulate ideas, answers, or statements from different perspectives. Figure 2 is a form of the problem presented in the animated video, where the problem is designed to be able to organize students so they can have the ability to provide different ideas.

Figure 2. Organizing problem students to different ideas

In the second stage, Organizing what students learn in this activity is learning with animated videos that can increase students' interest in learning, and students can survive in learning situations that they consider difficult because the context in the video is different from what they experienced before or can also be called new knowledge. With this new thing, creative abilities on the elaboration indicator increase because it stimulates broad thinking to solve existing problems. Figure 3 is a form of questions or problems presented in the animated video, where these problems are designed by presenting contextual problems. Contextual problems can help stimulate students' creative thinking skills to solve problems when faced with problems in the real world.

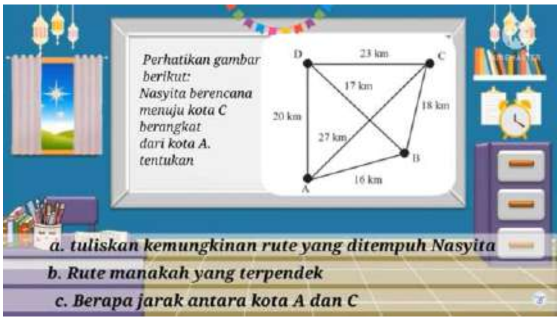

Figure 3. Presentation of Contextual Problems in Stimulating Creative Thinking Skills

Furthermore, the problems presented in the video also have another purpose. Presentation of contextual problems in stimulating creative thinking skills can also provide different ideas with *fluency and originality* (Bulu & Tanggur, 2021; Oktavia & Ridlo, 2020; Sanders, 2016).

In the third stage, independent and group investigations in this learning activity, students are encouraged to collaborate with their group mates (Semilarski et al., 2021). In this activity, it is essential to share several tasks according to the ability of its members (level) (Alfares, 2021; Rustan & Bahru, 2018; Zorlu & Zorlu, 2021). Gather information from the material and discuss it with the group (Farochmah & Leonard, 2021).

Figure 4. Group Discussion Activities

Discussion activities with groups as presented in Figure 5, where these activities are contained in the video. The teacher gives instructions in the video for all students to discuss with their respective groups. Discussion activities can be in the form of activities when the teacher gives a problem. A selected member from each group presented the group discussion results in front of the class and then responded to the other groups. This discussion activity can produce different ideas (flexibility) (Hasanah et al., 2023; Priangga, 2021; Rizal et al., 2020). In addition, discussion activities in the video and those carried out by students directly when given problems can help students solve problems and find solutions. Therefore, it is expected that students will be able to complete the task (general) and provide their answers using the solutions obtained in the discussion activity (de Lima et al., 2019; Steinbauer et al., 2021; Vidyastuti et al., 2022). The fourth stage is developing and presenting student work (Silva et al., 2018). In these activities, students are expected to increase self-efficacy on self-confidence to present themselves in front of the class. The hard work completed is also important to be presented even though it is beyond his ability (Fathiah Umriani, 2020).

In the fifth stage, which is shown in Figure 5.

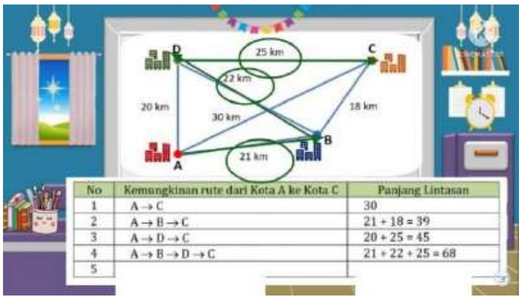

Figure 5. Analysis and evaluation presentation of the contextual problem-solving process

Figure 5, presented in the animated video, a step-by-step format for analyzing and evaluating the problem-solving process, the student can give different thoughts from others due to the stimulation given to the learning (Ambarsari & Eliastuti, 2017; Masitoh & Fitriyani, 2018). The problem-solving stage can also develop different answers from different angles. The problems give students many ways, solutions, and answers (Arnidha & Fatahillah, 2021; Dewi & Harjono, 2021; Prayogi & Asy'ari, 2013).

Self-efficacy is very influential in problem-based learning assisted by video animation—the effect of this learning on self-efficacy when solving a given problem. Students with high self-efficacy can solve problems very well (Amalya et al., 2021). PBL can potentially increase self-efficacy because it is based on constructivism; effective learning occurs when students reconstruct their knowledge through learning experiences (Masitoh & Fitriyani, 2018). Using innovative learning resources can also affect self-efficacy. One of the innovative learning resources in question is animated videos, as in this study.

Constructivist learning can enhance creative thinking skills (Kardoyo et al., 2020). One problem-learning model is problem-based learning. This is consistent with research findings (Aminy et al., 2021) that the problem-based learning model supported by GeoGebra is highly effective in improving creative thinking skills. This research (Fathiah Umriani, 2020) is also reinforced by the presence of learning media used in problem-based learning models to improve students' creative thinking skills.

Limitation

The limitation of this study is that researchers in managing classes are not very flexible because the class being researched at this time is a class that already exists—limitations in selecting students' abilities randomly. Students who have low abilities or are less skilled at speaking in group discussions to solve problems, these students are also less active in working with their friends.

Implication

Using video-assisted PBL can help the teacher organize students with various characteristics in informing learning objectives and describing essential needs. So that students have a solid motivation to be actively involved in problem-solving activities in class to increase students' self-efficacy and creative thinking ability.

CONCLUSION

To conclude, by the findings, the impact of self-efficacy and creative thinking skills is significantly different for students who are better taught in problem-based learning with video animations than those who are not. N-Gain's values analysis in this study reveals that the increasing differences in pre-test and post-test scores for practical classes are more significant than for the control class. Analysis of the N-gain value criteria shows that animation of the video-assisted problem-based learning model is more efficient than typical learning models. Thus, the effect of problem-based learning models supported by animated videos on students' self-efficacy and creative thinking ability is superior to traditional learning models.

The recommendation from the researcher for the readers and researchers is to develop a more focused worksheet. So that all indicators of creative thinking ability can achieve the minimum criteria, It is necessary to conduct further research on using problem-based learning models assisted by video animation and whether they consistently increase the ability to think creatively, mathematically, and independently in mathematics learning.

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The Development of *Adobe Flash CS6*-Based Interactive Media to Improve Numerical Literacy Skills for *Madrasah Ibtidaiyah* Students

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Abstract

It is essential to improve students' numeracy literacy skills to apply concepts in everyday life and interpret information correctly, so interactive learning media is needed to support this. However, teachers need to be more optimal in using interactive learning media so that numeracy literacy skills are low. This study aimed to develop interactive media based on Adobe Flash Media CS6, the development used as ADDIE. The stages of this research model include Analysis, Design, Development, Implementation, and Evaluation. The results of this study indicate that the development of interactive learning media based on Adobe Flash CS6 can improve numeracy literacy skills. This can be seen from the average percentage of validity of 87% with very valid criteria, media expert validation of 78.3% with valid criteria, and practitioner validation of 94.2% with very valid criteria, besides that the average percentage of practicality obtained from the results of the black box testing questionnaire on five different types of android devices and types, 100% was successfully used. The percentage of effectiveness was 0.49, and the criteria were moderate. For this reason, interactive learning media based on Adobe Flash CS6 can be used as alternative learning at Madrasah Ibtidaiyah to improve numeracy literacy skills.

Keywords: Adobe Flash CS6; Numerical Literacy; Interactive Media; Improve; Madrasah Ibtidaiyah

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Abstrak

Kemampuan literasi numerasi siswa penting untuk ditingkatkan agar siswa dapat mengaplikasikan konsep dalam kehidupan sehari-hari serta menginterpretasi informasi dengan baik, sehingga diperlukan media pembelajaran interaktif untuk mendukung hal tersebut. Namun guru belum maksimal dalam menggunakan media pembelajaran interaktif sehingga kemampuan literasi numerasi rendah. Tujuan penelitian ini adalah untuk mengembangkan media interaktif berbasis adobe media flash cs6, pengembangan yang digunakan adalah ADDIE. Adapun tahapan dari model penelitian ini meliputi: Analysis, Design, Development, Implementation, dan Evaluation. hasil dari penelitian ini menunjukkan bahwa pengembangan media pembelajaran interaktif berbasis adobe flash cs6 dapat meningkatkan kemampuan literasi numerasi. Hal ini dapat dilihat dari rata-rata persentase kevalidan sebesar 87% kriteria sangat valid, validasi ahli media sebesar 78,3% kriteria valid, dan validasi praktisi sebesar 94,2% dengan kriteria sangat valid, selain itu rata-rata persentase kepraktisan yang diperoleh dari hasil angket uji coba blackbox testing pada 5 perangkat android yang berbeda jenis dan tipe sebesar 100% berhasil digunakan dan persentase keefektivan sebesar 0,49 kriteria sedang. Untuk itu media pembelajaran interaktif berbasis adobe flash cs6 bisa digunakan alternatif pembelajaran di Madrasah Ibtidaiyah untuk meningkatkan kemampuan literasi numerasi.

INTRODUCTION

The development of Information Technology (ICT)-based learning media, in general, has contributed to numerical literacy skills. Interactive media is very well used to improve the quality of students' numeracy (Miller, 2018). This is in line with the opinion put forward by Letwinsky (2017), which stated that when access to technology becomes more abundant, educators must realize the potential expansion of the benefits of using ICT to foster numerical literacy. Therefore ICT-based learning media plays an essential role because it can be used to make learning exciting and positively impact academic performance (Chuang, 2014, p.1969), in this case, numerical literacy skills.

However, based on the results of observations and interviews with several fifth-grade teachers, it was found that teachers only used *WhatsApp* media as an intermediary for delivering matters. *WhatsApp* was not only an intermediary for providing matters but also a means of communication between teachers and students.

MI Darussalam Brengkolo uses WhatsApp media to make learning videos that contain the flow of learning activities, namely opening activities (orientation), core activities (explanation of material), and closing activities (evaluation or assignment). Then they upload the video to *youtube* and will send the link via *WhatsApp*. The problem is that when online learning was carried out, students were less motivated if the learning activities were only limited to providing matters through learning videos.

This happens because teachers only used monotonous learning methods with closed questions, which impacted students' numerical literacy skills. Closed questions here defined as routine questions that are closed and can be directly solved by using a formula (Kartikasari, Kusmayadi, & Usodo, 2016). Even though on the other hand, students ideally need questions with mathematical reasoning, such as PISA (Putri, 2017).

To overcome the problems stated above, researchers offer interactive learning media to help students learn independently and with guidance. The media developed is a *Flash*-based application media which is also expected to help teachers deliver learning matters. The advantages of *Flash* media are not only used for web applications (Fanani, 2006) but can be developed to build desktop applications. The learning media developed by researchers can be used by students offline on their *Android* devices without using the internet after installing it. Apart from being used on *Android*, this media can also be used on a PC.

This interactive learning media was developed using computer software, namely *Adobe Flash CS6*. *Adobe Flash* is a computer software specifically designed by *Adobe* and is a standard professional authoring tool application program used to create animations, webs, and interactive and dynamic applications. *Flash* is designed to create reliable and lightweight 2-dimensional animations, so *Flash* is widely used to build and provide animation effects on websites, interactive multimedia, animated films, games, and others (Atiaturrahmaniah & Ibrahim, 2017). *Flash*-based interactive media was developed containing learning objectives, matter summaries, exercises, and discussions, and supporting interactive learning multimedia packaged as innovative, effective, and practical. With this *Flash*-based interactive media, student learning activities are hoped to become more active, fun, and motivated.

Rahmaibu has carried out some previous research on learning media using similar software (2016) and stated that students had good conceptual understanding and completeness criteria above 86%. In addition, *Adobe Flash* media also received positive responses from students, and the media is effectively used in learning. Umbara and Nuraeni (2019), in their research results, explained that learning media using *Adobe Flash CS6* were considered suitable for use and succeeded in adding value to learning outcomes and students' literacy interests. In addition, Krismadinata (2019) research obtained results that the content contained in interactive media proved valid, practical, effective in improving learning outcomes, and valuable when used in learning activities. This is reinforced by research conducted by Mustarin *et al* (2019), which stated that learning activities became alive with the application of interactive learning media with *Adobe Flash CS6* in class. The use of these media also affects students' metacognition skills (Madinda, 2022).

Based on the results of research on *Adobe Flash* media, there has yet to research on numerical literacy skills, so in this study, it is necessary to develop media to improve numerical literacy skills. Numerical literacy skills are essential to give to students because, in the current era of globalization, people with the skills to discover new concepts, open networks, and the competence to meet high work standards are needed (Yusuf & Hayat, 2010). When a person has numerical literacy skills, that person can apply concepts in everyday life and interpret information well (Pangesti, 2018). The literacy skills in question are (1) mathematical communication skills, (2) mathematization skills, (3) representation skills, (4) reasoning and argumentation skills, (5) skills in devising problem-solving strategies, (5) skills to use symbolic, formal, and technical language, and (7) skills to use mathematical tools (OECD PISA; 2012). In addition, numerical literacy also involves mathematical reasoning (Purwasih, 2018), which gives students the power to use mathematical thinking in solving everyday problems to be better prepared to face life's challenges (Stecey & Tuner, 2007). Thus, this study focuses on developing *Adobe Flash* Media to improve numerical literacy skills in the mathematics subject of fractions.

METHODS

This research used the research and development type. This research was conducted in the fifth grade of MI Darussalam Brenggolo Kediri. In learning in fifth grade, most of the teachers used

WhatsApp as a learning medium, so learning is less interactive. This research was conducted to produce a product and test its feasibility. The product being developed was interactive learning media using *Adobe Flash CS6* software in the fifth grade of MI mathematics subject on addition and subtraction of fractions subject matter. The development model used is the Lee and Owens development model. The primary reason for this interactive learning media development model is using the Lee and Owens development model because this model is devoted to developing multimedia (Lee & Owens, 20004).

The development steps, according to Lee and Owens are: (1) Assessment/Analysis, which is divided into two parts, namely needs assessment and front-end analysis; (2) Design; (3) Development; (4) Implementation; (5) Evaluation. The development procedure is shown in Figure 1 as follows.

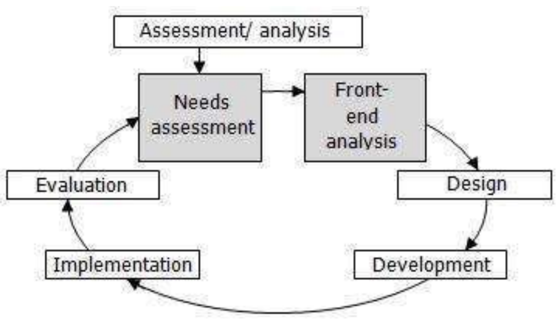

Figure 1. The Development Procedure (William W. Lee & Diana L. Owens, 2004)

Following the type of research, the type of data used in media development research is in the form of quantitative and qualitative data types. Quantitative data were obtained from validation questionnaire scores from experts and field practitioners (teachers), student response questionnaires, Black Box testing questionnaires, and the results of pre-test and post-test assessments. Meanwhile, qualitative data were obtained from interviews, criticisms, and media validators' suggestions. In this research, three types of data analysis techniques were used: **(1)** the validity analysis was obtained from validation questionnaire scores of matter experts, media experts, and field practitioners (homeroom teachers) with a questionnaire rating score ranging from 1 to 5. These scores were analyzed using a Likert scale in Table 1 and then managed with the validity formula.

Table 1. Likert Scale

No	Score	Description
1	Score 1	Very imprecise, inappropriate, unclear, unattractive, and not easy.
2	Score 2	Imprecise, inappropriate, unclear, unattractive, not easy.
3	Score 3	Sufficiently precise, appropriate, clear, attractive, and straightforward.
4	Score 4	Precise, appropriate, clear, attractive, and straightforward.
5	Score 5	Very precise, appropriate, clear, attractive, and straightforward.

(Source: Sugandi & Rasyid, 2019)

Validity Percentage Formula:

$$p = \frac{\sum X}{\sum X_1} \times 100\%$$

Description: p= percentage of validity score, $\sum X$= sum of experts' answers in one aspect, $\sum X_1$= maximum sum of answers in one aspect, 100%= constant (Sugandi & Abdur Rasyid, 2019).

Once the validation score was known, the results were described by looking at the validation criteria in table 2 below.

Table 2. Validation Criteria

No	Achievement Level	Qualification	Description
1	81% - 100%	Very Good	Very Valid
2	61% - 80%	Good	Valid
3	41% - 60%	Sufficient	Quite Valid
4	21% - 40%	Less Good	Less Valid
5	0% - 20%	Very Poor	Invalid

(Source: Damayanti, et al., 2018)

(2) the practicality analysis was obtained from the Black Box testing results in data which were carried out in small group trials of 5 *Android* users. The data obtained were then analyzed using the Guttman scale in table 3. The variables in the questionnaire were measured from two categories: a checklist with a score of 1 for the answer "Yes" and a score of 0 for the answer "No".

Table 3. Guttman Scale

No	Score	Description
1	Score 1	Agree / Yes
2	Score 0	Disagree / No

(Source: Sugiyono, 2018)

Practicality Percentage Formula:

$$p = \frac{\sum X}{\sum X_1} \times 100\%$$

Description: p = percentage of practicality score, $\sum X$ = sum of experts' answers in one aspect, $\sum X_1$ = maximum sum of answers in one aspect, 100% = constant (Sugandi & Abdur Rasyid, 2019).

Once the practicality score was known, the results were described by looking at the practicality criteria in table 4 below.

Table 4 Practicality Criteria

No	Achievement Level	Qualification	Description
1	81% - 100%	Very Strong	Very Practical
2	61% - 80%	Strong	Practical
3	41% - 60%	Quite Strong	Quite Practical
4	21% - 40%	Weak	Less Practical
5	0% - 20%	Very Weak	Impractical

(Source: Damayanti *et al*, 2018)

(3) the effectiveness analysis was obtained from students' numerical literacy data by conducting a pre-test and post-test on large group trial activities conducted on 42 fifth-grade students of MI Darussalam Brenggolo. The formula for calculating numerical literacy skills is as follows.

$$S = \frac{T}{T_t} \times 100\%$$

Description: S = numerical literacy score for each student, T = total score obtained, T_t = maximum total score, 100% = constant (Ariska, Darmadi, & Murtafi'ah, 2018).

Afterward, to calculate the difference in the significance level between the pre-test and post-test evaluation results, researchers used the N-Gain Score test to measure students' numerical literacy skills before and after using interactive learning media with the following formula.

$$N - Gain = \frac{Post - test\ Score - Pretest\ Score}{Maximum\ Score - Pretest\ Score}$$

Based on the formula, the criteria for increasing numerical literacy can be seen in table 5 as follows.

Table 5 N-Gain Score Criteria

N- Gain Score	Criteria
N-Gain > 0,7	High
0,3 ≤ N-Gain ≤ 0,7	Moderate
N-Gain < 0,3	Low

(Source: Majdi, Subali, & Sugianto, 2018)

RESULTS AND DISCUSSIONS

This research and development results were in the form of *Adobe Flash*-based interactive mathematics learning media on addition and subtraction of fractions matter for fifth graders of Elementary School/MI. The results of media development products that researchers have developed are presented in the following figure.

Figure 2. Start Page

Figure 3. First Login Page

Figure 4. Second Login Page

Figure 5. Main Page

Figure 6. Exercise Menu Page

Figure 7. Game Menu Page

The steps conducted by researchers in developing *Adobe Flash*-based interactive mathematics learning media are as follows.

Analysis

There are two parts to the analysis stage needs assessment and front-end analysis. Needs assessment is an activity carried out to analyze field conditions and students and analyze the subject matter that will be used as a source in product development. The problems found by researchers in field studies include: (1) students needed supporting media that can assist in learning both with guidance and independently; (2) students needed learning media that can be accessed offline so that it can help reduce the level of data purchases they complain about; (3) students did not understand fractions subject matter because there are too many sub-matter so they needed media that can summarize the subject matter practically; (4) the unavailability of interactive learning media in mathematics, especially for addition and subtraction of fractions subject matter; (5) students needed more fun learning variations. From the results of these data, researchers developed interactive mathematics learning media using *Adobe Flash CS6* software as a learning tool for fifth graders of MI Darussalam Brenggolo.

Design

The design stage is the initial planning stage for making interactive learning media products. This includes activities to determine the specifications of the developed media, the structure of the developed media subject matter, making explanations of the subject matter and designing questions about addition and subtraction, fractions for fifth grade SD/MI students, creating flowcharts and media storyboards developed with the *Balsamiq Mockup* application, as well as the preparation of the assessment instrument used to obtain the developed media validity score.

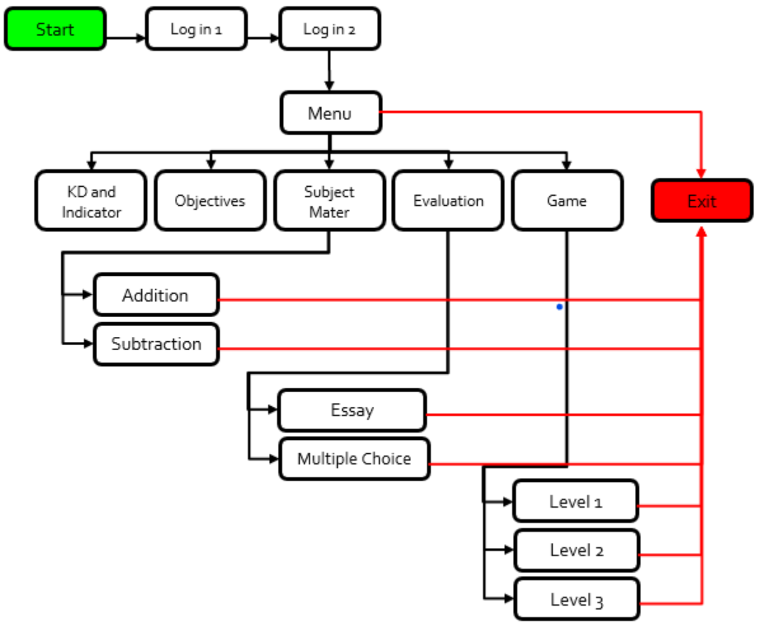

Figure 8. Flowchart for the Media Development

Development

Researchers carry out the media development stage to assemble all components, such as material, images, animation, music, and others, into an interactive learning media product. To make it happen, researchers need the following things: (1) Laptop/Computer with minimum specifications as follows: Processor = 133 Mhz Intel Pentium; OS =Windows 95/98/NTA/2000 *Professional;* RAM = 32 MB, and HDD = 40 MB; (2) *Adobe Flash CS6 application to make a media program*; and (3) *Audacity* application to create sound effects.

Then, the media was designed and developed according to the flowchart and storyboard designs. The following is a flowchart for the development of media design used in this research (see Figure 8).

After making a flowchart design, researchers made storyboard designs for the display designs of interactive learning media using *Balsamiq Mockup* application which is shown as follows.

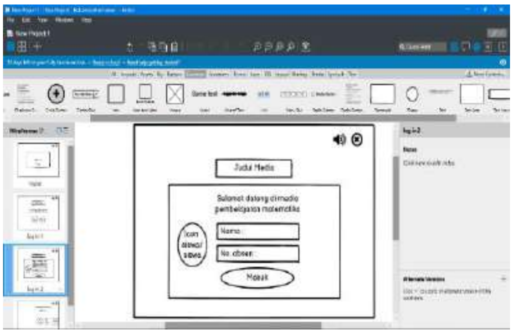

Figure 9. Storyboard Making

After making the storyboard (see Figure 9), the researchers looked for the necessary pictures and animations. They then designed them as an interactive learning media interface design that included button designs, writing designs, background designs, and others. In this stage, researchers used *Adobe Illustrator CC2018* application.

The steps for media development, namely (1) create a media interface design with *Adobe Illustrator CC2018* application; (2) create a learning media with *Adobe Flash CS6* application; (3) arrangement of Black Box testing; (4) Black Box testing; (5) publishing interactive learning media; (6) and lastly, validating media products.

Implementation

The implementation stage is the stage of testing learning media products developed to know whether the media is appropriate or not to be used. A team of experts determined at the design stage carry out this stage, namely matter experts, media experts, and field practitioners, to carry out media validation. After the expert team tried out the media, the trial result was revised to perfect the product before being implemented to students. Next, researchers continued with small-group trials and large-group trials. The results of the data analysis on the product's validity, practicality, and effectiveness are described as follows.

Media Validity Analysis

Validation by Matter Experts

There were two validations by matter experts used in this research. The researchers used a questionnaire sheet containing 15 questions by matter experts. First, matter experts validated on May 1^{oth}, 2022, and the second was on May 15th, 2022. The validation results were obtained with an average percentage of 87% with very good/very valid validity criteria. This follows the results of research conducted by Krismadinata (2019) that the results obtained are that the content contained in interactive media is proven valid, practical, and effective. Thus, the numerical literacy matter in the media was feasible to use. This follows the research results by Krismadinata (2019) that interactive media was proven valid and practical in improving students' learning skills and valuable when used in learning activities. In addition, the matter expert validators also conveyed several things that needed to improve in the media: (1) the need to improve learning indicators, (2) the need to adjust students' and teachers' animations according to the characters of MI students, (3) the need for variations in numerical literacy questions to suit everyday life, and (4) the need for sound recordings of subject matter explanations as a facility for all types of student learning.

Validation by Media Experts

Two validators also carried out validation by media experts. This media validation assessment was seen from the appearance and programming aspects of learning media using a validation questionnaire sheet containing 24 questions. Based on these two aspects, an average percentage of validity of 78.3% was obtained with the Good/Valid validation criteria. The conclusion obtained was that this interactive learning media is feasible to use. The media expert validators also conveyed several things in the media that needed to improve, including making the background color different in each section, adding animated images, placing exit buttons, shortening learning objectives, and increasing the font size.

Validation by Field Practitioners

Validation by valid practitioners was carried out by field expert validators, namely homeroom teachers of the fifth grade of MI Darussalam Brenggolo. The field practitioners' assessment combines validation from matter experts and media experts, including appearance, ease of use, matter presentation, and media benefits. This validation activity used a validation questionnaire sheet that contained 15 questions. It was obtained that the average percentage of interactive mathematics learning media validity was 94.2% with very good/very valid validity criteria. Thus, this interactive learning media is feasible to use. Field practitioners also conveyed several things to improve the media, namely the need for other matters and the addition of matters other than writing.

Media Practicality Analysis

Practicality analysis was obtained from Black Box testing activities in small group trials by 5 *Android* users with different brands and types. This test was carried out after researchers improved the media according to the expert validators' criticisms and suggestions. This test was used to determine the functionality of the learning media software and whether it was functioning correctly or not. The results of the Black Box testing that was carried out proved that the percentage of media functionality has a perfect result, namely 100% . Therefore, the developed media can run and function properly without any errors.

Media Effectiveness Analysis

Effectiveness analysis was obtained from large group trials and post-test evaluation activities. This test was carried out by 42 fifth-grade students of MI Darussalam Brenggolo, Kediri Regency, using their respective *Android*(s). Based on the results of the analysis of the pre-test and post-test evaluations, it was found that in the pre-test results, three students scored ≥ 75 with a maximum score of 75. Meanwhile, in the post-test results, of students who scored ≥ 75, 31 students with a maximum score of 100. It was necessary to do a classical calculation between the pre-test and post-test to calculate the completeness score of numerical literacy.

The classical percentage of the completeness score of numerical literacy before using interactive learning media (pre-test) was 7.14%. The classical percentage of the completeness score of numerical literacy after using interactive learning media (post-test) was 73.8%. Based on the calculations, the students' classical numerical literacy results were 7.14% on the pre-test and 73.8% on the post-test. Afterward, the calculation of the significance level using the N-Gain Score test was carried out. From the calculation results, the N-Gain Score obtained was 0.49. This score is 0.3 ≤ n-gain ≤ 0.7, which surpassed the medium criteria. This showed an increased in the medium category in students' numerical literacy after using developed interactive learning media. This follows the results of Umbara and Nuraeni (2019) research that learning media using *Adobe Flash CS6* is considered appropriate and has increased student literacy. From the detailed description, it can be concluded that this *Adobe Flash*-based interactive learning media was quite effective in increasing students' numerical literacy, and the class atmosphere was more interactive than before. This follows the results of research conducted by Mustarin *et al* (2019), which stated that learning activities become livelier with the application of interactive learning media with *Adobe Flash CS6* in class. The use of these media also affected students' metacognition skills (Madinda, 2022).

Evaluation

The evaluation stage was carried out by collecting data from the trials, namely validation by matter experts, validation by media experts, and validation by field practitioners to make improvements and follow up as suggested. Apart from experts and field practitioners, product evaluations were also obtained from small and large-group trials. The results of the evaluation data were used to determine which learning media is appropriate to be used as supporting media in learning mathematics on addition and subtraction of fractions subject matter.

Limitation

This study has limitations, including the number of students for product trials which causes various response results, and the number of validators for the product to see the accuracy and validity of the media used. In addition, this study was not conducted longitudinally to determine whether the effectiveness or influence of the media on students' numeracy literacy skills changed or remained over time. Nevertheless, the results of this study can be used as evidence that interactive learning media based on adobe flash cs6 can improve students' Numeracy literacy skills will not change.

Implication

The results of this study are expected to provide information to educators to develop learning media on other materials, to provide an alternative selection of learning methods in elementary schools to improve students' numeracy literacy skills. In addition, it can also be applied in schools at other high levels on other mathematical concepts.

CONCLUSIONS

The *Adobe Flash*-based developed interactive mathematics learning media was feasible to be used in learning activities, especially in mathematics subjects on addition and subtraction of fractions subject matter because it met the feasibility criteria. Based on the results of media feasibility in terms of media validity, the percentage of validation results obtained by matter experts was 87% in very valid criteria. The percentage of validation results by media experts was 78.3% in the valid criteria, and the percentage of validation results from field practitioners was 94.2% in very valid criteria. Furthermore, regarding practicality, the media obtained a 100% percentage result from the Black Box testing results. Afterward, regarding the effectiveness of the media in improving students' numerical literacy skills, the significance of the N-Gain Score obtained was 0.49 in the medium category. This proved that the learning media developed met the feasibility criteria of the media.

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Development of Curved Three-Dimensional Shape Learning Media Ethnomathematics-Based Using Augmented Reality

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Abstract

A learning media is needed that can make abstract mathematics understandable and applicable in the real world where learning media currently does not interact much with technology.This study aims to develop learning media that uses Ethnomathematics-based Augmented Reality in the *Gunungan* tradition, which is valid, practical, and effective. The research subjects for the trial class are junior high school class IX students, with one class as a small class, one as a large class, and one as a control class. The learning media developed in this study is Augmented Reality (AR) assisted learning media with a combination of real and virtual objects in a real environment. Based on the results of descriptive analysis, it was found that the learning media developed had good quality because it met valid, practical, and effective criteria. The development of Augmented Reality-based spatial media can be used as a supporting medium for mathematics in grade 9 junior high school.

Keywords: *Ethnomathematics; learning media; Augmented Reality*

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Abstrak

Media pembelajaran diperlukan untuk membangun abstraksi agar matematika lebih mudah dipahami dan diterapkan dalam dunia nyata dimana media pembelajaran sata ini belum banyak berinteraksi dengan teknologi. Tujuan penelitian ini adalah untuk mengembangkan media pembelajaran yang menggunakan Augmented Reality berbasis Etnomatematika pada tradisi Gunungan yang valid, praktis dan efektif. Subyek penelitian untuk kelas uji coba adalah siswa kelas IX SMP, dengan satu kelas sebagai kelas kecil, satu kelas sebagai kelas besar, dan satu kelas sebagai kelas kontrol. Media pembelajaran yang dikembangkan dalam penelitian ini adalah media pembelajaran berbantuan Augmented Reality (AR) dengan perpaduan antara benda nyata dan maya dalam lingkungan nyata. Berdasarkan hasil analisis deskriptif diperoleh bahwa media pembelajaran yang dikembangkan berkualitas baik karena memenuhi kriteria valid, praktis, dan efektif. Pengembangan media augmented reality berbasis media dimensi tiga ini dapat digunakan sebagai media pendukung untuk pembelajaran matematika di kelas 9 SMP.

INTRODUCTION

Mathematics learning is often considered by students as difficult learning (Bakhrodin, Istiqomah & Abdullah 2019). This has an impact on the low achievement in learning mathematics Indonesian students. Because mathematics learning in general is still centered on the material in the book. Learning is a systematic and systemic process of teaching and learning activities. Learning is carried out to achieve learning objectives. The learning process should be interactive and communicative between the teacher and the student. But in fact, the learning process sometimes becomes communication from one direction, since students tend to be inactive and only listen to explanations from the teacher. According to Apriliyani & Mulyatna (2021), students are not interested in the learning process, especially mathematics learning. This is in line with the opinion (Nadiyah, Wijaya, Hakim, 2019) which reveals that it is undeniable that in every series of mathematics learning activities, student learning motivation is still relatively low. This can be seen from the lack of students desire to learn, and less interesting learning activities because students tend to be passive and rarely ask questions.

Therefore, a learning medium is needed that can make abstract mathematics understandable and applicable in the real world. Meanwhile, it is necessary to balance learning between concepts in schools and traditional culture in realizing contextual learning that is following the expectations of the 2013 curriculum (Lin, Chen & Liu 2017). To be able to create an atmosphere of learning mathematics that is closely meaningful as in everyday life (Herlina, 2020). So that a teacher has an important role in carrying out culture-based mathematics learning so that learning can be more easily accepted and does not seem to be something far from real life (Abdullah, 2016).

Based on these conditions, it is necessary to have learning related to daily problems, one of which is through culture. Therefore, learning innovations that use a cultural approach is needed by connecting teaching materials with daily life. The mathematics connected with the local culture is called Ethnomathematics (Khomah, 2020). Through ethnomathematics, students can learn mathematics through real activities so that they can construct and understand abstract mathematical concepts (Anjarwati, 2022; Nursyahidah and Albab, 2021). Noto, Firmasari & Fatchurrohman (2018) state that the application of ethnomathematics to learning approaches is an alternative to conveying mathematics more interestingly and overcoming saturation. In addition, culture-based mathematics learning is an interesting and innovative alternative because it encourages the emergence of contextual meanings based on student experiences in the life of cultural societies (Fajriyah, 2018). In addition, learning using ethnomathematics can stimulate students' problem-solving abilities (Nursyahidah, Saputro, and Robowo, 2018).

Thus, students can cultivate a sense of love and cultural ownership when learning mathematics which can certainly help students not to get bored and not to feel lazy (Rizki & Frentika, 2021). In general, mathematics learning is still rare and integrates various local cultures that can be related to mathematics, one of which is *the Gunungan* Tradition. Central Java has a variety of local cultures, one of which is the *Gunungan* Tradition. In *the Gunungan* tradition, students can relate to geometric material that is still abstract.

Geometry is included in one of the branches of mathematics that is the subject of learning mathematics at various levels. Learning cannot only be done by knowledge transfer but must also be done by forming concepts through a series carried out directly by students (Nurhasanah et al. in Fauzi & Arisetyawan, 2020). Thus over time, the development of information technology is increasingly advanced which certainly affects human life (Mustaqim et al, 2017). Therefore, in facing the learning and development of 21st-century technology, one of them is by utilizing *Augmented Reality* technology (Rampengan, 2015). Augmented Reality is an application that combines the real world with the virtual world in two-dimensional and three-dimensional forms projected in a real environment simultaneously (Mustika & Sanjaya 2015). With the use of technology associated with Ethnomathematics, it is hoped that mathematics learning will no longer be boring. This learning media aims to increase students' understanding of the material to build space so that it is expected to help students more easily understand the material.

Based on the above problems, this study aims to describe the development of android-based mathematics learning media using augmented reality technology with an ethnomathematics approach at the junior high school level. The development of this learning media aims to invite students to build mathematical concepts from the real world, using their smartphones with an ethnomathematical approach (Richardo, et al., 2019). The real-world context used in this study is the cultural context which is a *mountain* tradition. While smartphones act as a bridge between cultural contexts and mathematical concepts, which in this case use applications based on augmented reality.

Based on the background stated, the purpose of this study is to develop an ethnomathematics-based curved three-dimensional shape learning media using Augmented Reality.

METHODS

The method used in this study is ADDIE (Branch, 2009) which is arranged into 5 stages, namely: analysis, design, development, implementation, and evaluation. The method can be seen in figure 1.

Stage 1: Analysis (analysis*)*, which consists of an early-end analysis. The stage of activity carried out is to identify the problems encountered in the learning process to build a curved side room. In addition, a study of the availability of mathematics learning media was also carried out. The results of this analysis will be used as the basis for the development of mathematics learning media; student analysis. Activities are carried out to find information from the teacher to obtain the characteristics of students of class ix, the background of academic abilities, as

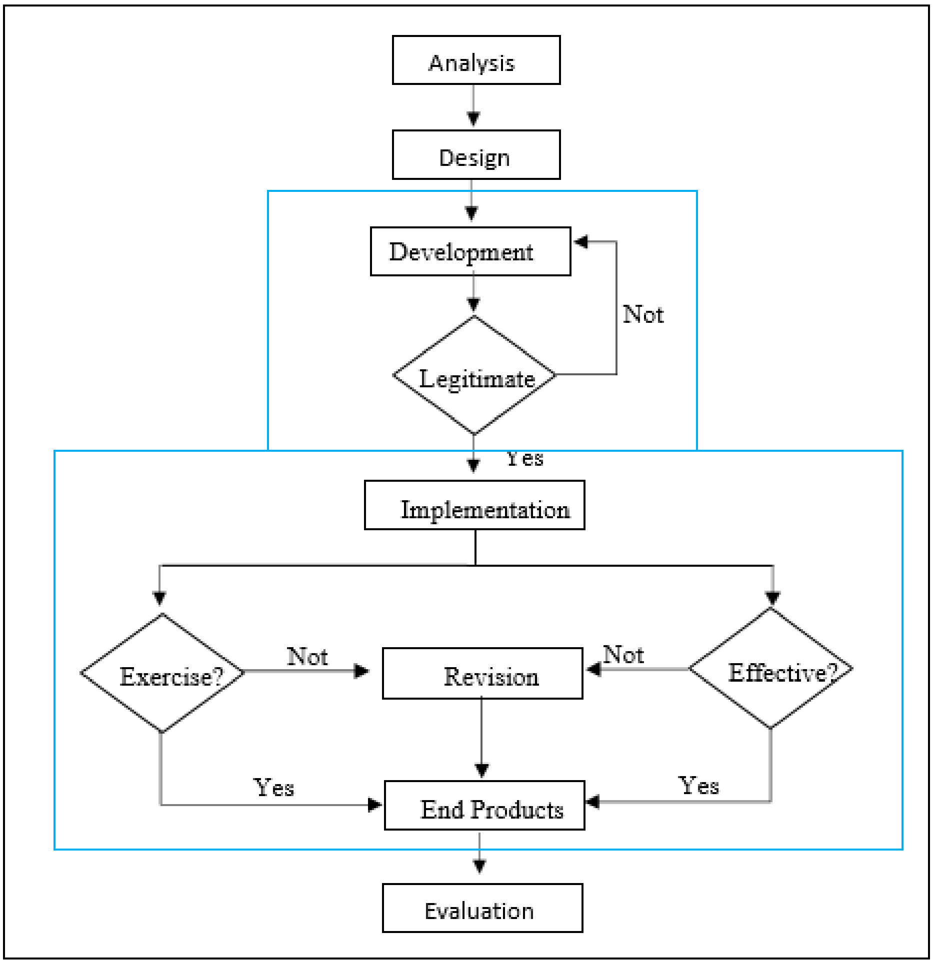

Figure 1. Development Procedure with the ADDIE Model (Branch, 2009)

well as the background of skills. The results of the analysis are used as instructional information to design learning media to build curved side rooms. and material analysis. Material analysis is carried out to mark, summarize, structure, and arrange mathematical objects such as facts, concepts, and procedures on the material to build curved side rooms that students will study. The material for the curved 3D shapes taught refers to the curriculum applicable in the high school that is the research site, and the teacher's book and student book used are books issued by the Ministry of Education and Culture.

Stage 2: Design, consisting of the following steps: creating a learning path. This stage creates a learning flow where the arrangement in the media is following the order of learning that corresponds to what is applied in the school according to the results at the analysis stage; drawing up the content of the substrate. At this stage, the media is compiled and designed its contents according to the created plot and according to the material resulting from the analysis, and the creation of a display design. At this stage, the media is designed to look in such a way that the appearance of the media can increase the attractiveness of the use of the media to be created later.

Stage 3: Development, consisting of stages: media creation. After all the previous stages are completed, the creation of design media 1 is carried out, the media is made according to the design that has been designed. Media creation using *blender, unity, and vuforia* software; preparation instructions for use. After the design of 1 substrate is completed, then make instructions for use. The goal at this stage is for students to easily operate the learning media. At this stage, the media produced according to design 1 is corrected or recreated according to the assessment, correction, and input of the validator. Validation by media expert validator Mr. M. Prayito S.Pd., M.Pd. Conducted to obtain assessments, inputs, or comments from experts regarding the format, content, and illustrations of learning media, the beauty of design on AR media, and application systems. Validation by material expert validator Dr. Ida Dwijayanti, M.Pd is carried out to obtain assessments, inputs, or comments from experts regarding aspects of language, material suitability, and media uniqueness. So that after validation and it has been declared valid, a draft media 2 is obtained; and trials. At this stage, after design 2 is obtained, it is tested limited to a few students in the teaching and learning process. Before the teaching and learning process takes place, students are given *a pre-test*. At the second meeting, students were given treatment that was carried out in groups, and each student's activities were observed and recorded. At the last meeting, students were given *a post-test.* After all the complete data that has been obtained from the results of *the pre-test, post-test*, and observation are analyzed.

Stage 4: *Implementation.* At the implementation stage, learning is carried out using learning media to 34 students in large classes, and students in control classes carry out learning as usual. The results of the implementation stages determine whether there are significant differences in android-based learning media if applied in learning and also the results of completing classical learning for students who take part in learning using android-based augmented reality media. Stage 5: Evaluation, at this stage, the results of the data obtained during the implementation are analyzed. After the data analysis of was is completed, the media is evaluated. Whether the media is effective or not.

RESULTS AND DISCUSSION

Results

The process of developing android-based learning media that is feasible for learning materials to build curved side rooms is to use the ADDIE development model, namely: *Analysis (Analysis).* Results at this stage are 1) The background of students' abilities and students' creative thinking skills. Students' ability to understand curved 3D shapes materials is still relatively low, judged by pretest results that show a classical average score below KKM; 2) The background of the student's learning experience. The learning experience of students using android media is still small because students more often follow learning with conventional learning. Design. The results at this stage are in the form of learning media design which includes: 1) Learning flow. The results of the learning flow design used in the design of learning media are learning paths that have been discussed with teachers who teach mathematics subjects in schools according to Figure 2.

At the beginning of the lesson, students will be reminded again of the previous material, which is the material for 3D shapes by asking questions about the material. Then students orient the problem by using the illustrations that are in groups. After students understand the existing problems, students and their groups solve the problems that have been presented in the worksheet by collecting data related to the material. When the data and problems have been solved, students present the results of their analysis in front of the class. In the findings of this study, it is hoped that students can learn the material

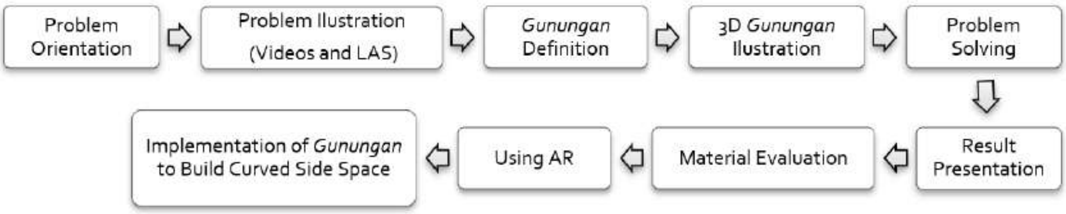

Figure 2. Learning Path

Figure 3 Screen Design

of curved 3D shapes easily using ethnomathematics-based Augmented Reality media, which helps students imagine the shape of curved 3D shapes concretely and makes classroom learning less monotonous. In addition to learning with media that support learning, students are also still taught to get to know Indonesian culture.

After the presentation of the results and analysis is complete, it is continued with the evaluation and strengthening of the material using *Augmented Reality (AR)* media. 2) The content of the media. The content of the learning media is the understanding of the mountain tradition based on its implementation of the curved 3D shapes that have been discussed with the teacher who teaches mathematics subjects, and 3) Display design. The display design drawings can be seen in Figure 3.

Development. Activities at this stage are 1) Media creation. The result is learning media created using *Blender, Unity, and Vuforia* by design software; 2) *Validation*. The media created and the instruments that have been compiled are validated by material experts and design experts to obtain validation. Revisions are made based on suggestions from validators. The revision is done by fixing *AR* Media by adding background music as per validator instructions. The results of the revisions are carried out continuously following the suggestions of the validators

Table 1. Results of Teacher Observations in Managing Learning

No.	Teacher Activities	Valuation
Introduction		
1	The teacher's ability to focus students' attention at the time of learning initiation	4
2	Ability to motivate and arouse student interest	4
3	Ability to convey learning objectives and learning steps	4
4	The ability to alert prerequisite materials	4
Core Activities		
1	Ability to make presentations/demonstrations using *smartphone* media	3
2	Ability to assist students who have difficulty using *smartphones*	4
3	Ability to provide feedback on students' understanding of the material *contained in smartphones*	4
4	Ability to motivate students to work and study using *smartphones*	4
Cover		
1	Ability to infer learning that has been discussed in *smartphone* media	4
2	Ability to close learning	4
3	Ability to condition the classroom atmosphere, including the enthusiasm of students and teachers	4
Mood		4

and the final result is stated that the media and instruments are valid; 3) Trials. Media and instruments are tested in small classes and show results that media and instruments are worth using.

Implementation. Media and learning instruments from the results of the development stage were then implemented in 34 students in large classes. Data from the results of the implementation are collected and analyzed.

Evaluation. The results of this stage are an evaluation of the results of data analysis in the previous stage, which shows that the final results of android-based learning media curved 3D shapes have met the categories of valid, practical, and effective. The implementation of the learning media trial was carried out in class IX SMP N 11 Semarang.

The data that have been obtained in the research process of developing android-based learning media for learning to build curved side rooms are analyzed and explained as seen in Table 1.

Observation of the teacher's activities in managing learning is carried out by one of the observers. The assessment of each observation criterion of teacher activity is successfully studied following the predetermined assessment criteria and is contained in each observation sheet. Based on the results of the analysis of teacher activities, managing learning to build curved side rooms to improve student understanding when learning lasts until the end of learning meets the criteria of "Excellent".

The teacher's activity in managing learning at the trial stage is observed with the results in Table 1 The results of data analysis show that the scores of each aspect of assessment in learning are 3 and 4 or can be said to be "Good" and "Excellent" with mode 4. This kind of value indicates that the teacher's activity in managing learning is categorized as "Excellent" in learning activities. The implementation of learning using this media is only as a facilitator to direct and guide as necessary, as well as encourage students to understand and solve problems according to their respective abilities. This is in line with (Lin, Chen, Liu, 2017) that teachers in conventional classrooms are transformed into different settings where ICT media are involved in the learning process. Where the role of the teacher who was originally purely providing information turns into a facilitator where students are directed to find more information and determine the truth of the information.

Judging from the teacher's activities during the learning process, it shows that the learning media created has fulfilled its objectives, namely as a support for learning in understanding the material, and improving the quality of learning meetings as conveyed by (Branch, 2009) this is in line with the opinion (Branch, 2009; Sari, 2018) that the media can expand the ability of teachers in teaching, and offering opportunities to strengthen learning without being seen repeatedly for students.

Based on the observation of the results of student activities during learning to build a curved side room using android-based learning media, then at the time limit, 1 meeting is faster than learning time without using media. Thus, it can be said that students build curved side rooms using android-based learning media during learning activities to improve students' understanding of meeting active criteria. Students' responses to learning using media can be seen in table 2.

Based on the results of the analysis of student responses in Table 2, most students gave positive responses to the material being taught, how the teacher taught and each learning component received a positive response from students. This proves that student responses to the use of android-based media in learning activities to increase student understanding fall into the "Positive" category. This shows that students feel happy and interested in learning curved side shapes using Android-based media.

In Table 2, the responses of students who chose the happy category for the use of media in learning activities averaged 96% with a 100% mode in the student response questionnaire. This shows that students' responses tend to be happy or interested in participating in learning activities on curved side shapes using Android-based media.

Table 2. Results of Student Response Questionnaire to Media Used

Statement	Answer	
I feel good about the following learning components	Happy	Not
Learning material is good	100%	0%
How teachers teach is interesting	100%	0%
I can clearly understand the language used in smartphone learning media	100%	0%
The display (writing and illustrations/images) in *smartphone learning media* is very interesting	100%	0%
With smartphone-assisted math learning, it becomes easier to understand the material for curved 3D shapes	Yes 80%	Not 20%

Completion of Classical Learning

To see the completion of learning can be seen in Table 3 and Table 4.

Table 2. Pre-test and Post-test Results

Initial name	Pre-test	Posted	n-again	Learning Completion
C.S.A	56,5	85,5	0,666	Complete
E.R.F	56,5	85,5	0,666	Complete
F.D.S	64	90	0,722	Complete
F.A.A	64	90	0,722	Complete
M.J.M	75,5	100	1	Complete
Y.C	75,5	100	1	Complete
Middle	65,333	91,833	0,796	
0,764 N-high gain				

Table 4. Post-test Results of Experimental Class and Control Class Students

Control Class	Experimental Class
50	77,5
50	82,5
50	85
50	85
60	92,5
65	92,5
65	92,5
65	92,5
65	92,5
65	92,5
65	92,5

Table 3 Test Results- T
Test Paired Samples

		Paired Differences							
		Mean	Std. Deviations	Std. Error Means	95% Confidence Interval of Difference		t	Df	Sig. (2-tail)
					Lower	Above			
Pair 1	Pretest - Post	-31,76471	22,50866	3,86020	-39,61835	-23,91106	8,229	33	,000

Based on the results of the table, it was obtained that the completion of individual student learning in experimental classes and experimental classes was achieved by 100%. All students completed learning with a KKM score of 75, because all students in the trial class and experimental class had the lowest score of 77.5 and the highest score of 100, so it was categorized that all students from the trial class and experimental class "Complete Learning". In addition, the data obtained from the pre-test and post-test in the form of tests have been validated by expert validators. Each question item given has been declared valid so that each question item in the pre-test and post-test has been declared suitable for use as a source of data collection.

Improvement in student comprehension based on the descriptive statistical analysis in table 3 was obtained and the increase in student comprehension is categorized as "High". The n-gain results from the pre-test and post-test showed a score of 0.764, or it can be called > 0.7 so it is included in the category of high comprehension improvement. In addition, the data obtained from the pre-test and post-test in the form of tests have been validated by expert validators. Each question item given has been declared valid so that each question item in the pre-test and post-test has been declared suitable for use as a source of data collection in the results of the analysis in the trial class described in the previous section, it can be stated that: 1) The test results to improve students' understanding of the experimental class are classically complete. This can be seen in Table 4 which describes the post-test results in the experimental class and control class.

In Table 5, it can be seen that the post-test results of each student in the experimental class have the lowest score of 77.5 while the highest score is 92.5. Since the lowest score is 77.5 and when compared with KKM 75, then the score of 77.5 can be said to be complete so it can be said that the student's comprehension test results are classically complete; 2) A significant influence on students' learning comprehension by using learning media.

This can be seen from Table 5 which explains the results of the T-test on the pretest and post-test data in the experimental class. In the table, it can be seen that the signification value (2-tailed) in the T-test is 0.000 < 0.05, so it can be said that learning media has a significant effect on students' understanding of curved 3D shapes materials. It can be stated that the learning media developed can be declared effective

Based on the descriptive statistical analysis in table 3 it is obtained that the improvement in student experience is categorized as "High". The n-gain results from the pre-test and post-test showed a score of 0.764, or it can be called > 0.7 so it is included in the category of high comprehension improvement. In addition, the data obtained from the pre-test and post-test in the form of tests have been validated by expert validators. Each item of the question given has been declared valid so that each item of the question in the pre-test and post-test, it has been declared feasible to be used as a source of data collection.

Discussion

After being analyzed using the application, the results of the analysis of student learning outcomes data are shown in table 5. Table 5 describes the T-test results against post-test result data in the experimental class and control class. In the table, it can be seen that the signification value (2-tailed) in the T-test is 0.00 or it can be said to be <0.05, so it can be said that the development of learning media has a significant effect on students' learning about curved 3D shapes materials. This is following the results of previous research that the use of technology as a learning medium in the classroom can increase understanding so that students can learn more effectively (Eyyan & Yaratan, 2014; Hennessy & Dunham, 2002; and Lin, Chen, Liu, 2017).

To find out the effectiveness of learning media to build android-based curved 3D shapes, it is implemented and declared effective if it meets the following aspects: 1) Test results to improve student understanding are completed classically. Provided that the aspects of learning completion are met; 2)There is a significant influence on understanding. This study has important theoretical implications for the literature on AR namely, that these two modalities have different cognitive demands on users. However, the cognitive demands of such immersive experiences can make AR a more effective medium for conveying auditory (or other nonvisual) information. When designing an AR experience, it may be best to communicate relevant information in a hearing format.

Implication

The development of Augmented Reality-based spatial media can be used as a supporting medium for mathematics in grade 9 junior high school to improve creative thinking skills, to be a medium to support the creation of a good atmosphere in class, and to be a medium to support students in constructing geometric shapes abstract into 3D forms which are explored through the *Gunungan ethnomathematics context.*

Limitation

This study has various limitations. The limitations of this study are as follows: (1) This research is focused on the development of media using AR on curved 3D shapes; (2) The time required for this research is quite short so that media development can be carried out in a more complete and sophisticated manner so that it can have a greater effect on the development of student's creative thinking skills and can be improved to support students' HOTS abilities.

CONCLUSION

The results of the development of learning media using the ADDIE model that has been described, *ethnomathematics-based Augmented Reality-assisted learning* media are said to be valid with validation results from material experts and media experts of 90% with valid and very good criteria used, said to be practical as shown by the results of student response questionnaire analysis by 80%, and effective for improving creative thinking ability the students are shown by analyzing the post-test results of each student in the experimental class has the lowest score of 77.5 and when compared to KKM 75, a score of 77.5 can be said to be complete so that it can be said that the student's post-test results are classically complete. In addition, the use of Ethnomatematics-based Augmented Reality technology can increase students' interest in curved side geometric material, students can associate *gunungan* context with the characteristics, volume, and surface area of the material they are studying, and students can solve problems related to volume and area problems. the surface of tubes, cones, and balls.

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Development of Mathematical Modelling Teaching Materials on Mathematics Perception of Junior High School Students

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Abstract

21st-century mathematics learning emphasizes students to think critically, communicate, collaborate, and connect mathematics with the real world. This is in line with mathematical modeling which focuses on learning mathematics using real-world phenomena in the process of solving problems that require understanding and interaction. This study aims to produce mathematics teaching materials based on mathematical modeling in the context of Indonesian forest conservation that has criteria for validity, practicality, and a potential effect on students' mathematical perceptions. The type of research used is design research with development studies. Data collection techniques used questionnaires, interviews, and documentation. Teaching materials were declared valid based on expert review questionnaire assessment and student assessment at the one-to-one evaluation stage. The total questionnaire score was 4.59 with a very valid category. Teaching materials are declared practical based on students' comments at the small group stage and analysis of teaching material completion documents at the field test stage. Furthermore, this study uses the principles of developing mathematical modeling problems according to Gailbraith which can produce mathematical modeling teaching materials that have a potential effect on students' mathematical perceptions, with a questionnaire score of 63% in the very good category.

Keywords: *Indonesian Forest Conservation Context; Mathematical Modelling; Teaching Materials; Students' Mathematics Perception.*

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Abstrak

Pembelajaran matematika abad-21 menekankan peserta didik untuk berpikir kritis, berkomunikasi, berkolaborasi serta menghubungkan ilmu matematika dengan dunia nyata. Hal tersebut sejalan dengan pemodelan matematika yang memfokuskan pembelajaran matematika menggunakan fenomena dunia nyata dalam proses penyelesaian masalah yang membutuhkan pemahaman serta interaksi. Penelitian ini bertujuan untuk menghasilkan bahan ajar matematika berbasis pemodelan matematika konteks konservasi hutan Indonesia yang memiliki kriteria kevalidan, kepraktisan serta memiliki efek potensial terhadap persepsi matematika peserta didik. Jenis penelitian yang digunakan adalah penelitian design research dengan tipe development studies. Teknik pengumpulan data menggunakan angket, wawancara dan dokumentasi. Bahan ajar dinyatakan valid berdasarkan penilaian angket expert review dan penilaian peserta didik pada tahap one to one evaluation. Total skor angket sebesar 4,59 dengan kategori sangat valid. Bahan ajar dinyatakan praktis berdasarkan komentar peserta didik pada tahap small group dan analisis dokumen penyelesaian bahan ajar pada tahap field test. Selanjutnya, penelitian ini menggunakan prinsip pengembangan soal pemodelan matematika menurut Gailbraith yang dapat menghasilkan bahan ajar pemodelan matematika yang memiliki efek potensial terhadap persepsi matematika peserta didik, dengan skor angket persepsi sebesar 63% berkategori sangat baik.

INTRODUCTION

One of the goals of learning mathematics today is that students can solve problems that require the ability to understand problems, design mathematical models, solve problems, and interpret solutions to be resolved (MoEC, 2022). This goal can be represented by mathematical modeling that can support the mathematics learning process in the classroom (Blum & Ferri, 2009; Burkhardt, 2018; Chan, 2019; Lu et al., 2021). With mathematical modeling, students can be motivated to develop a mindset in solving real-world problems to prepare studentsforn the future (Blum & Niss, 1991; Kunwar, 2021; Niss & Blum, 2020).

However, in reality, educators don’t know the importance of mathematical modeling so students are not required to think independently in solving problems (Bahir, R. A., & Mampouw, 2020; Simalango, M. M., Darmawijoyo, & Aisyah, 2018). In line with that, the PISA test which uses the same framework as the mathematical modeling framework shows that Indonesia's score in 2018 is still below the average of OECD countries, where only 2.3% of students reached level 5 mathematics (OECD, 2019). In research (Pranitasari, D., & Ratu, 2020), students still have difficulty in solving PISA level 4, 5, and 6 questions that involve reasoning, interpretation, and argumentation.

Nowadays, Mathematics learning is still trapped in the orientation of understanding material and numeracy skills so it has not been able to develop skills in thinking (Fadillah, F., & Munandar, 2021; Surmayanta, & Wibawa, 2020). The research of (Utari et al., 2019) that mathematics is still a difficult and boring lesson so it makes low math learning outcomes. This is supported in bye research of (Najic & Winarso, 2016) which says that students' perceptions of mathematics are related to the methods used. Therefore, a pleasant learning process will lead to a good perception of learning mathematics and influence good math learning outcomes.

To foster good perceptions of mathematics learning, the problems given must be close to students (Chamila et al., 2016; Lisnani et al., 2020; Putra et al., 2016). Therefore, using a real context can make math learning more effective and can reduce students' negative perceptions of mathematics (Boaler, 1993). The context used in this study is Indonesian forest conservation, where forests are one of the national problems in Indonesia (MoEF, 2020; Wijayanti, 2007).

Based on these problems, teaching

materials with mathematical modeling stages are used to help students work independently in solving problems (Saputri & Zulkardi, 2020). The principles in mathematical modeling can train students to construct knowledge to solve real problems (Blum, W., Gailbraith, P., Henn, H.-W., & Niss, 2007; Gailbraith, P., & Holton, 2018). Furthermore, with mathematical modeling learners can make a positive contribution to the process of learning mathematics in real life (Özdemir & Üzel, 2012). Thus, the purpose of this study is to develop junior high school mathematics teaching materials based on mathematical modeling using the context of Indonesian forests that are valid, practical, and have a potential effect on students' mathematical perceptions.

METHOD

This research uses a type of design research with development studies, which consists of two stages, namely the preliminary research stage and the prototyping stage (Akker, J. V., Gravemeijer, K., McKenney, S., & Nieveen, 2006). In the first stage, researchers analyzed the existing context and research problems adjusted to the literature review and theoretical development of design analysis. In

Figure 1. Flow of Formative Evaluation
(Tessmer, 1993)

the second stage, we used the formative evaluation stage (Tessmer, 1993) which consists of self-evaluation, expert review, one-to-one evaluation, small group, and field test. The flow of formative evaluation used can be seen in Figure 1.

At the expert review stage, the research subjects consisted of material, product, and language experts. At the one-to-one evaluation stage, the research subjects consisted of 3 students. The small group stage consisted of 9 students and ate field test, stage consisted of 30 nintninth-gradedents at Palembang Junior High School 1. The selection of learners as research subjects was wereried out based on learner abilities, student interests, and student personalities. student interests can show proper motivation to learn and review instructions during evaluation, as well as personality and self-confidence to express criticism during evaluation. So, the selection of learners was based on these three things with high, medium, and low criteria selected by their mathematics teachers. In the small group and field test stages, students must be balanced in each group.

The implementation of one-to-one evaluation, and small groups is carried out for 45 minutes. Where learners complete the teaching materials provided individually at the one-to-one stage and collaborate with their group friends in small groups. Learners can ask the researcher if there are things that make them confused or if they experience difficulties. The researcher manages the evaluation to encourage learner confidence and communication, as the success of the evaluation depends on the learners. In the field test, learning was carried out like a normal class, starting with introductory activities, followed by core activities using mathematical modeling teaching materials and closing activities. The learning process at the field test stage was carried out by the math teacher and the researcher served as an observer.

The data collection techniques used in this study were questionnaires, and documentation. The questionnaire used is a validation questionnaire, as well as a questionnaire of students' perceptions of mathematics. The validation questionnaire is used to see the validity of teaching materials with assessments made by material experts, product experts, language experts. teaching materials meet valid criteria if the assessment score is categorized as good and based on revisions from expert comments. The score obtained from the expert is summed up and divided by the number of questions given in the questionnaire. The following is the validity category based on the score obtained:

Table 1. Validity Assesment Categories

Average Score (x)	Category
4,20 < x	Very Valid
3,40 < x ≤ 4,20	Valid
2,60 < x ≤ 3,40	Simply
1,80 < x ≤ 2,60	Less
x < 1,80	Very Less

Furthermore, practicality is assessed from the documentation in the form of students' solutions which are analyzed according to the steps of mathematical modeling.

The students' perception questionnaire was used to see the potential effect on students' mathematics perception after the teaching materials were given. After the data were collected, the questionnaire scores were categorized based on Table 2.

Table 2. Questionnaire Scores Categories

Score Range	Criteria
$Mi + 1{,}5SDi \leq \bar{M} \leq Mi + 3{,}0SDi$	Very Good
$Mi + 0SDi \leq \bar{M} \leq Mi + 1{,}5SDi$	Good
$Mi - 1{,}5SDi \leq \bar{M} \leq Mi + 0SDi$	Enough
$Mi - 3SDi \leq \bar{M} \leq Mi - 1{,}5SDi$	Less

Description: Mi = Ideal mean | SDi = Ideal standard deviation

The maximum score is 15 and the minimum score is 3, where there are 3 questions on each math perception indicator.

RESULTS AND DISCUSSION

Results

The first stage is preliminary research stage, the researcher conducted an analysis in the form of problem analysis and context analysis.

Preliminary Research

At this stage, researchers conducted an analysis in the form of problem analysis and context analysis by conducting interviews with the deputy head of curriculum is also a mathematics teacher.

One of the real contexts close to students is the problem of Indonesian forest conservation, it is necessary for students to understand the importance of reforestation and deforestation activities to protect our environment. In line with this, mathematical modeling is a suitable tool used to solve the Indonesian forest problem.

Based on the results of the previous analysis, in the process of learning junior high school mathematics, a facility is needed to make a positive contribution to learning mathematics and reduce negative perceptions for students towards learning mathematics so that the mathematics learning process becomes more effective. Therefore, mathematics teaching materials were developed based on the principles of developing mathematical modeling according to (Blum, W., Gailbraith, P., Henn, H.-W., & Niss, 2007) as follows:

Table 3. Principle of Developing Mathematical Modelling

Problem Design
Problems are developed about real-world
Problems consist of questions that lead learners in solving the problem, such as information that must be known before solving the problem. What they need to do to solve the given problem.
There is a question that asks learners to come up with assumptions and mathematical formulations.
After formulating, learners are expected to interpret the solution they get to the effect that planting trees and reducing deforestation has on the environment.
The problems developed are didactical and contain systematic problems. The problems developed contain steps so that students can solve the problems themselves.

After developing the problem, the stages of solving are based on the stages of mathematical modeling which consist of understanding the task, searching mathematics, using mathematics, and explaining the results (Niss & Blum, 2020).

Prototyping Stage

The prototyping stage in this study uses the formative evaluation stage (Tessmer, 1993). The following results of the prototyping stage are explained as follows:
Self Evaluation

In the self-evaluation, the researcher checks to see obvious errors in the product. Where there are several changes, namely: 1) Eliminating the title of the mathematical modeling stage so that students are not confused about the meaning of the sentence. 2) Changing the word "assumption" to "suppose". 3) The last change lies in changing the solution used, where the calculation of the reforestation area up to 2030 is completed first and then continued with the calculation of the remaining deforested area in 2030. After making revisions, the prototype I was obtained, and will be tested at the one-to-one evaluation and expert review stages to see the validity of teaching materials based on mathematical modeling.

Expert Review

The expert review stage is an evaluation in terms of content accuracy as well as technical quality. Experts who evaluate teaching materials consist of content experts, and instructional design experts.

The followings are the comments and suggestions given by the experts on the prototype I along with the follow-up actions taken:

Table 4. Comments Expert

Comments and Suggestions	Revised
The learning objectives are quite limited, readjust what you want to achieve with the completion of the teaching material.	The learning objectives were revised and adjusted again to the teaching materials and the stages of mathematical modeling used.
Question 1—4 which includes *understanding tasks* on mathematical modeling is more specified with questions that make students better understand the problems given.	The question was revised to only 1 question that represents the beginning of students' understanding of completing the teaching materials in the context of Indonesian forest conservation.
Add complexity to the problem through information on deforestation activities that have increased a% or are constant each year.	Added a question to calculate the area of Indonesia's forests by adding complexity to the problem through information on deforestation activities that have increased by a% or are constant each year.
The context used is very interesting for mathematical modeling, but the problems should be made more *open-ended* to get learners used to being a "modeler".	Based on these comments, the questions were revised to become *open-ended* problems.

Furthermore, the expert also gave a validity score which will be presented in Table 5.

Table 5. Teaching Material Validation Result

Aspects	Average score	Quality
Content	4,8125	Very Valid
Construct	4,4	Very Valid
Language	4,56	Very Valid
Overall	4,59	Very Valid

One-to-One Evaluation

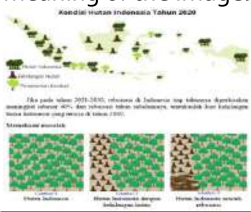
From the results obtained at the expert review stage, researchers also conducted a one-to-one evaluation. One-to-one evaluation involved one-by-one student and a researcher. Students assessed the intrinsic quality through the criteria of clarity, ease of use, sequencing, and completeness. The importance of one-to-one is to provide information from the learner's or user's point of view, where the researcher can maximize the information because they talk directly with students.

At the one-to-one evaluation stage, students solved the problems along with providing comments on the teaching materials provided. During this time, the researcher records the information and reactions given by the students. Since one-to-one relies heavily on student comments in reviewing instructions, information is usually obtained spontaneously. This can also be supported by asking questions such as why students are confused or having difficulty and if students find something interesting.

The results of the one-to-one evaluation found that one of the students had difficulty understanding the sentence of question number 5 "Based on understanding 1, calculate the area of reforestation of Indonesia's forests in 2021-2030", where students have not been able to complete the calculation of the area of reforestation of Indonesia's forests from 2021-2030. The sentence made him focus on the year instead of the nith year reforestation area. Furthermore, researchers provide interventions so that students can solve them and make revisions in the future on the question.

Then, one of the students also commented that the images used must contain consistent images so that the images given have a connection with each other. The following are the results of revisions that have been made at the one-to-one evaluation stage:

Table 6. The result of One-to-One Stage

Before Revision	After Revision
The image of the condition of Indonesia's forests in 2020 in the caption Indonesian forests and replanting is not the same as images 1, 2, and 3 which can lead to misunderstanding of the meaning of the image. 	The picture was revised by making the Indonesian forest picture and the replanting picture the same as pictures 1, 2, and 3. 

Teaching materials can be said to be valid if they are by the objectives of formative evaluation, namely acceptance of the product and the strength of the product from the aspects of relevant content, and consistent constructs (Akker, J. V., Gravemeijer, K., McKenney, S., & Nieveen, 2006). In this study, the validity of teaching materials can be seen from expert comments, student comments, and validity scores in Table 2. Where, the content is the independent curriculum, as well as learning objectives and the needs of students. In terms of construct, it can be seen the suitability of teaching materials with the principles and steps of mathematical modeling with the level of ninth-grade studninth-gradealidity score in Table 2 shows very valid criteria. This means that the teaching materials developed are by the facts, this relates to the quality of the construct and content of the teaching materials.

Furthermore, the results of revisions at the expert review stage and the one-to-one evaluation stage, and production prototype II will be tested at the small group stage.

Small Group

As opposed to one-to-one, small groups focus on student performance to confirm instruction within the group. Thus, the researcher is only an observer and intervenes only when necessary. At this stage, the researcher will identify the clarity of the instructions and the effectiveness of the teaching materials. Furthermore, evaluation in small groups can improve the implementability or the degree to which the instruction can be used appropriately in the environment. It can also provide information about the ease of use and attractiveness of instructions for teachers. This is commonly referred to as practical. The results obtained in the small group stage trial and the revisions made are as follows.

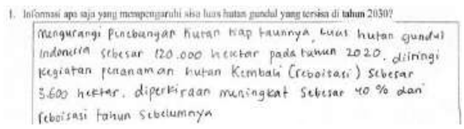
Table 7. The Result of Small Group Stage

Before Revision	After Revision
The sentence "What information must be known to determine the area deforested in 2030?", are understand but some answers are more extensive than expected.	Revise the sentence of question 1 to read "What information affects the remaining area of deforestation in 2030?" to be more specific.
Revision to Definition 1 where there is $referring$ to a specific year so that according to MB, MS, FK, and FA the sentence can be clarified again.	Revise the sentence in Definition 1 to make it clearer and easier to understand.
Question 2, according to MB and FK, contained the same meaning as question 3.	Adding the phrase "every year" so that learners understand the question that the expected solution is the calculation every year.
In the sentence counting declining deforestation a% clarified, are learners freed to determine the a that?	To make the sentence in the question clearer, it was revised into 2 questions, first students are devoted to choosing how much the decline in deforestation should be determined, and in the next question students are asked to complete the calculation.
The last question about the earth's temperature did not have a clear impact on forest conditions.	Replace the impact of forest conditions on learners' environment.

Based on the revision results at the small group stage, the teaching materials have met the practical criteria, namely, the clarity of instructions that have been revised from before and the implementation power of teaching materials is suitable for junior high school students to produce prototype III which will be tested at the field test stage.

Field Test

Field tests are evaluations to improve instruction and assess the effectiveness of instruction. Field tests are declared not to require further revision when students who still answer incorrectly are less than 30% of the total number of students. Here is one of the group answers based on the mathematical modeling stage.


1. Informasi apa saja yang mempengaruhi sisa luas hutan gundul yang tersisa di tahun 2030?

Mengurangi Penebangan hutan tiap tahunnya, luas hutan gundul Indonesia sebesar 120.000 hektar pada tahun 2020, diiringi kegiatan penanaman hutan Kembali (reboisasi) sebesar 3.600 hektar, diperkiraan meningkat sebesar 40 % dari reboisasi tahun sebelumnya

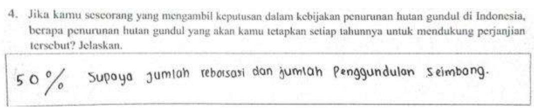
Translate: what information affects the area of remaining forest in 2030? Reduce deforestation each year. Indonesia's deforested area was 120,000 hectares in 2020 and was accompanied by a reforestation of 3600 which is estimated to increase by 40% from the previous year's reforestation.

Figure 2. Understanding Task Group 1

Figure 2 shows that group 1 and group 5 can understand the problems given about the condition of Indonesia's forests. All learners in their groups have fulfilled the *understanding task* stage contained in the teaching materials based on mathematical modeling. Furthermore, at the stages of *searching mathematics* and *using mathematics* in problem number 2, students have also been able to solve it, as seen in Figure 3 group 5 can determine the area of reforestation for each year from 2020 to 2030.

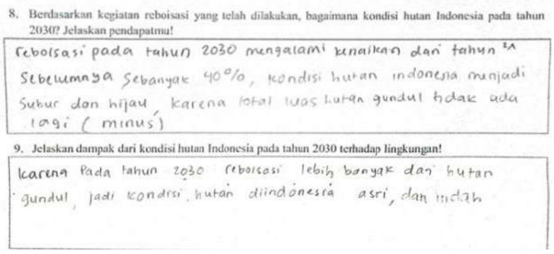
Figure 3 Group 5 Searching Mathematics and Using Mathematics Answer (see Appendix for clearer fig.)

At the *searching mathematics* stage, learners can see the data or information they need next as they make assumptions to solve the next problem. This can be seen in Figure 4, where there is one of the answers of students in their group made assumptions about the decline in deforested forests in Indonesia.



Translate:50% so that the amount of reforestation and the amount of deforestation are balanced
Figure 4. Group 5 Searching Mathematics Answer

The last stage in mathematical modeling according to (Niss & Blum, 2020) is the *explaining result stage*, where at this stage students interpret the results of the calculation of the remaining area of Indonesian forests in 2030 that they get, and make conclusions about the impact of reforestation and deforestation activities on the environment (Figure 5). The following are the learners' answers at the *explaining result* stage.



Translate: 8. Based on the reforestation that has been carried out, what will be the condition of Indonesia's forests in 2030?
Reforestation in 2030 has increased from the previous year by 40%, the condition of Indonesia's forests will be fertile and green because there are no more bare forests.
9. Describe the impact of Indonesia's forest condition in 2030 on the environment!
Because in 2030 reforestation is more than deforestation. So, the condition of Indonesia's forests will be beautiful.
Figure 5. Group 3 Explaining Result

From the results of students' solutions, it is found that most students can solve the problems given correctly and can fulfill the stages of mathematical modeling given. During the learning process, the teacher had no difficulty in implementing the learning process with teaching materials. Students understood the instructions given by the teacher, students could understand the material presented and students were active in their groups and actively expressed their opinions during the learning process. This also supports the practical criteria discussed at the small group stage.

Next is the administration of a mathematics perception questionnaire to see how the potential effect on students' mathematics perceptions after the teaching materials have been developed. The categories that will be seen in the perception questionnaire consist of interest, general utility, and need for high achievement (Luttrell et al., 2010). The following are the results of the students' mathematics perception questionnaire:

Table 8. The result of Student' Perception

Indicator	f	Percentage	Category
Interest	15	50%	Very good
	8	30%	Good
	6	20%	Simply
	0	0%	Less
General Utility	15	50%	Very good
	13	43%	Good
	2	7%	Simply
	0	0%	Less
Need for High Achievement	27	90%	Very good
	3	10%	Good
	0	0%	Simply
	0	0%	Less
Overall	57	63%	Very good
	24	28%	Good
	8	9%	Simply
	0	0%	Less

Based on the questionnaire results, the overall perception of students towards mathematics is very good after the learning process with teaching materials based on mathematical modeling in the context of Indonesian forest conservation. As seen in the table above, in the category of need for high achievement, the category is very good at 90%, this means that the student's assessment of the importance of learning mathematics is very good.

Discussion

In previous research (Riyanto, 2021; Sari & Darmawijoyo, 2019; Yusherlly, H & Darmawijoyo, 2020), there were developed student worksheet-based mathematical modeling with a financial context, a health context, and a parking fee context. This research develops mathematical modeling teaching materials within the context of Indonesian forest conservation which has valid, practical criteria and potential effects on students' mathematical perceptions.

The validity assessment is based on the validation questionnaire assessment by an expert review and student assessment at the one-to-one validation stage. The validity questionnaire score is 4.59 with a very good category (see Table 2), where good development must be by the construction used, in this case by the stages of mathematical (Niss & Blum, 2020). Furthermore, the need for a good assessment of the content of the teaching materials (Agustina & Farida, 2021), an assessment of the completeness of the teaching materials, the suitability of the learning objectives to be achieved with the curriculum, and the novelty of the content used.

Moreover, the assessment of students at the one-to-one evaluation stage consists of an assessment of the intrinsic quality in the form of clarity of teaching materials, ease of use, and completeness of teaching materials (Tessmer, 1993). In previous research (Yusherlly, H & Darmawijoyo, 2020), students completed teaching materials and commented on understanding the purpose of each question and whether there were sentences that seemed confusing. Furthermore, students assessed how the images in the teaching materials were, and whether the use of the context of everyday life in the form of the context of Indonesian forest conservation could attract them to the mathematics learning process. From the results of these assessments and revisions made, teaching materials have been said to be valid and produce prototype II which will be tested at the small group stage.

Practical assessment is based on students' comments at the small group stage and analysis of teaching material completion documents at the field test stage (Sari & Darmawijoyo, 2019). At the small group stage, the information to be obtained is the aspect of clarity of instructions and effectiveness of use. Furthermore, the field test stage looks at information about how the instructions are received by students, as well as the achievement of the expected learning objectives (Tessmer 1997). This can be seen in the answers of students who can solve problems with the stages of mathematical modeling well. Problems that are compiled from simple questions and leading students through the stages of mathematical modeling in solving them can make students solve problems well (Khusna & Ulfah, 2021; Saputri & Zulkardi, 2020). This is in line with this research, where at the field test stage students can solve the problems given appropriately, and actively in their groups. This can train students in constructing knowledge in solving problems by the principles of mathematical modeling. These results indicate that the teaching materials developed have met the practical criteria.

After the learning process at the field test stage has been completed, students are given a math perception questionnaire to see the potential effects after the teaching material is given. Perception is an impression through the senses received by the senses that are integrated into the individual(Riswandha & Sumardi, 20020). A good perception of mathematics for students is one of the factors in successful learning of mathematics (Boaler, 1993). The questionnaire score obtained in the excellent category was 63%, the good category was 28%, and the sufficient category was 9% (See Table 3). The interest indicator scored 50% in the excellent category and 30% in the good category, meaning that the teaching materials developed were able to encourage students' motivation to learn mathematics (Luttrell et al., 2010). By helping students to be interested in learning mathematics, it can make students aware of the importance of mathematics in everyday life which influences students' desire to get good achievements in learning mathematics.

Limitation

Students' perception of mathematics is limited by only using indicators that contain positive points, namely interesting, general utility, and need for high achievement. The personal cost indicator has not been assessed in this study.

Implication

The impact of this research is directly related to the current condition of the problem (environmental problem). That problem can make students appreciate and protect their environment. This research also has an impact on the development of environmentally sound learner attitudes by the current "Merdeka" curriculum. Of course, research on the development of mathematics teaching materials with environmentally sound has never been studied before.

CONCLUSION

The development of teaching materials that have been carried out and adapted to the principles of developing modeling problems can make students interested and motivated in learning mathematics. By giving problems that are directly related to the real world, such as the use of the context of Indonesian forest conservation, which is solved based on mathematical modeling, students understand the benefits of mathematics in everyday life. Where usually students think that learning math is just confusing symbols and not used in everyday life. Therefore, students are willing to work well in learning mathematics, as seen from the activeness of students in the mathematics learning process who work well together in groups, can present the results of the solutions they work on, and are brave in expressing their opinions in class discussions. These three points are in line with indicators of good student perceptions after providing teaching materials.

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Appendix

1. Informasi apa saja yang mempengaruhi sisa luas hutan gundul yang tersisa di tahun 2030?

mengurangi Penebangan hutan tiap taunnya, Luas hutan gundul Indonesia sebesar 120.000 hektar pada tahun 2020. diiringi kegiatan penanaman hutan kembali (reboisasi) sebesar 3.600 hektar. diperkiraan meningkat sebesar 40 % dan reboisasi tahun sebelumnya

Figure 2. Understanding Task Group 1

Luas reboisasi tahun 2021
$\left(\frac{40}{100} \cdot 3600\right) + 3.600$
= 1.440 + 3.600
= 5.040 hektar

Luas reboisasi tahun 2022
$\left(\frac{40}{100} \cdot 5.040\right) + 5040$
= 2016 + 5040
= 7.056 hektar

Luas reboisasi tahun 2023
$\left(\frac{40}{100} \cdot 7.056\right) + 7.056$
= 2.822 + 7.056
= 9.878 hektar

Luas reboisasi tahun 2024
$\left(\frac{40}{100} \cdot 9.878\right) + 9.878$
= 3.951 + 9.878
= 13.829 hektar

Luas reboisasi tahun 2025
$\left(\frac{40}{100} \cdot 13.829\right) + 13.829$
= 19.360 hektar

Luas reboisasi tahun 2026
$\left(\frac{40}{100} \cdot 19.360\right) + 19.360$
= 27.104 hektar

Luas reboisasi tahun 2027
$\left(\frac{40}{100} \cdot 27.104\right) + 27.104$
= 37.945 hektar

Luas reboisasi tahun 2028
$\left(\frac{40}{100} \cdot 37.945\right) + 37.945$
= 53.123 hektar

Luas reboisasi tahun 2029
$\left(\frac{40}{100} \cdot 53.123\right) + 53.123$
= 74.372 hektar

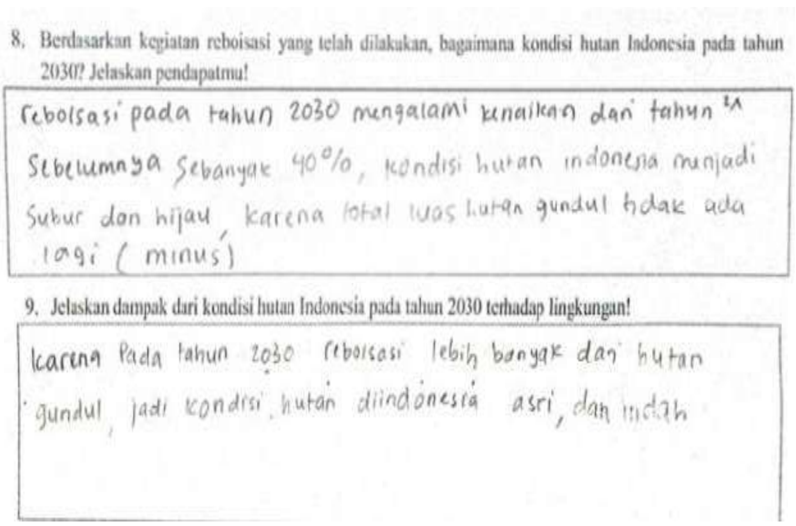
Luas reboisasi tahun 2030
$\left(\frac{40}{100} \cdot 74.372\right) + 74.372$
= 104.120 hektar

Figure 3. Group 5 Searching Mathematics and Using Mathematics Answer

4. Jika kamu seseorang yang mengambil keputusan dalam kebijakan penurunan hutan gundul di Indonesia, berapa penurunan hutan gundul yang akan kamu tetapkan setiap tahunnya untuk mendukung perjanjian tersebut? Jelaskan.

50 % Supaya jumlah reboisasi dan jumlah Penggundulan seimbang.

Figure 4. Group 5 Searching Mathematics Answer



8. Berdasarkan kegiatan reboisasi yang telah dilakukan, bagaimana kondisi hutan Indonesia pada tahun 2030? Jelaskan pendapatmu!

reboisasi pada tahun 2030 mengalami kenaikan dari tahun sebelumnya sebanyak 40%, kondisi hutan indonesia menjadi subur dan hijau, karena total luas hutan gundul tidak ada lagi (minus)

9. Jelaskan dampak dari kondisi hutan Indonesia pada tahun 2030 terhadap lingkungan!

karena pada tahun 2030 reboisasi lebih banyak dari hutan gundul, jadi kondisi hutan di indonesia asri, dan indah

Figure 5 Group 3 Explaining Result

Table 4. Expert Reviewer Resume result

Expert Reviewer	Content	Construct	Language
Expert 1	4,75	5	4,8
Expert 2	4,75	4,14	4,6
Expert 3	4,75	4,5	4,6
Expert 4	5	4	5
Expert 5	-	-	4,4
Expert 6	-	-	4
Average Score	4,8125	4,4	4,56

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Development of Codular-Based Mathbox Media to Improve Students' Self-assessment and Understanding of The Pythagorean Theorem

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Abstract

This study uses 'Matchbox' media which is focused and aims to improve students' self-assessment and understanding and is developed using the Codular website. The research method used is Research and Development (R&D) with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The development of this learning media proved to be valid with an average percentage of 95.45% of the 'Very Good' Media Checker criteria as measured using the Guttmann scale. There was an 11.1% increase in the pre-test to post-test self-assessment scores which were measured using a Likert scale. The difference in the scores of students' understanding tests with the Paired T-test shows that the application of media affects students' understanding test scores. Based on the results obtained, it can be concluded that the designed Codular web-based Mathbox media is a valid medium and can improve students' self-assessment and understanding of the Pythagorean theorem.

Keywords: *media development; learning media; self-assessment; Codular websites; Pythagorean theorem*

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Abstrak

Penelitian ini menggunakan media 'Mathbox' yang difokuskan dan bertujuan untuk meningkatkan penilaian dan pemahaman diri siswa, serta dikembangkan menggunakan website Codular. Metode penelitian yang digunakan adalah Research and Development (R&D) dengan model ADDIE (Analysis, Design, Development, Implementation, Evaluation). Pengembangan media pembelajaran ini terbukti valid dengan persentase rata-rata 95,45% kriteria validasi media 'Sangat Baik' yang diukur menggunakan skala Guttmann. Ada peningkatan 11,1% pada skor self-assessment pre-test hingga post-test yang diukur dengan menggunakan skala Likert. Perbedaan nilai tes pemahaman siswa dengan Paired T-test menunjukkan bahwa penerapan media berpengaruh terhadap nilai tes pemahaman siswa. Berdasarkan hasil yang diperoleh, dapat disimpulkan bahwa media Mathbox berbasis web Codular yang dirancang merupakan media yang valid dan dapat meningkatkan penilaian diri dan pemahaman siswa terhadap teorema Pythagoras.

INTRODUCTION

Pythagorean Theorem, as the primary material in the new curriculum, can be accepted by junior high school education level students. Studying the Pythagorean theorem is essential for calculating the distance and magnitude of the vector so that students can solve various problems related to the Pythagorean theorem (Roldán-Zafra et al., 2022). Leaving aside calculating the distance and magnitude of vectors, studying the Pythagorean theorem requires students first to have the ability to understand concepts to achieve one of the learning targets (Vellayati et al., 2020). This is because understanding concepts is a crucial and fundamental ability (Nichols & Howlett, 2021), as well as being the focus of mathematics learning activities (W. Lestari et al., 2021).

In mathematical terms, the ability to understand concepts not only helps students memorize formulas, but also can realize meanings in mathematics learning (Shofiah et al., 2021), and make it easier for students to solve mathematical problems (Jonsson et al., 2020). In addition to understanding concepts, self-assessment skills by students are also needed so that students understand what must be done in the learning process (Hairida, 2018). Self-assessment requires students to independently assess the status, learning process, and achievement of the material learned in learning by referring to the specified standards (Winarti & Rosyidah, 2020). In addition, self-assessment also assesses performance against predetermined criteria and aims to make students more independent, as well as to reflect on themselves (Abdillah et al., 2022). In simple terms, self-assessment is carried out to let students know the abilities that exist in themselves. As in the process of learning mathematics, learning the material of the Pythagorean theorem also requires these two abilities to achieve learning objectives (Tsai & Chin, 2022).

The Pythagorean theorem is classified as accessible material once you understand the concept. However, few students often experience problems solving various problems (Yuehuan & Zhou, 2022). In general, this is because students tend to memorize formulas, making it difficult for students to solve Pythagorean theorem problems (Towe & Julie, 2020). Not only that, the slow ability of students to receive material causes students to take longer to understand the material presented (Samo, 2021). These problems can be overcome by using excellent and appropriate learning media, such as learning media based on the Codular website.

Applications or software that are now widely used to develop learning media includes APPYPIE, Swishmax, Adobe Animate CC, Adobe Flash, Quizizz, Construct 2, and others. The Codular website has advantages in terms of simplicity, easy-to-understand features, availability of supporting devices, and easy operation (Syarlisjiswan et al., 2021). So that this gives the Codular website the potential to be used and optimized in the world of education such as learning media.

Codular is a website that provides tools similar to MIT App Inventor to create Android applications using block programming (D. A. Lestari, 2019). The existence of a block programming tool makes it easier for teachers to make applications through the Codular website because there is no need to type in program code manually (Srilatha et al., 2021). Based on the general understanding, learning can be said to be a tool, material, or learning material used by teachers and students in learning activities that are formed systematically (Aji & Setiyadi, 2020). This learning can help develop abilities in learning mathematics, such as problem-solving, understanding material concepts, mathematical connections, mathematical communication, and mathematical representation (Villeneuve et al., 2019).

Research on the topic of developing website-based learning media and applications has been carried out by several researchers. The research was conducted by Aditya (2018) regarding the development of web-based mathematics learning media on circle material for class VIII students. Research conducted by Aditya (2018) uses the web (e-learning), which still requires several instructor models and complete tools or materials. This research produced learning media in the form of a web that can only be accessed when a cellphone/laptop is connected to the internet. The research was conducted by Charissudin et al (2021) regarding the development of mathematics learning media with animation using the Swishmax application. This research develops animation as a learning medium, but delivering the Swishmax application still requires special equipment and abilities in making applications. Research conducted by Agung Saputro et al (2018) regarding the development of learning media using the application of Construct 2 to class VII Algebra material. Research conducted by Agung Saputro et al (2018) still uses html scripts which require users to have the ability to independently process scripts and learning media produced based on educational games. The novelty of this research compared to previous research is its simplicity, practicality, completeness of features that are easy to understand, availability of supporting devices, and production products in the form of Android applications which students can easily access via their respective cell phones.

From the preceding, it shows that "Development of Codular-Based Mathbox Media to Improve Students' Self-Assessment and Understanding of the Pythagorean Theorem" needs to be held because of its simplicity, practicality, completeness of easy-to-understand features, and the availability of supporting devices, able to help improve self-assessment and students' understanding of the material of the Pythagorean theorem. This study aimed to produce a Mathbox application based on the Codular website to improve students' self-assessment and understanding of the Pythagorean theorem. Hopefully, this research can be helpful for students and teachers in supporting teaching and learning activities and as a reference for other researchers who will develop website-based learning media.

METHOD

This research uses the Research and Development (R&D) method (Fadillah et al., 2021). Research and Development (R&D) are steps to develop or perfect an existing and accountable product (Fatmadiwi et al., 2021). In this study, Mathbox learning media based on the Codular website was developed using the ADDIE model, which consists of 5 stages of research, namely Analyze, Design, Development, Implementation, and Evaluation (Pangestu & Setyadi, 2020).

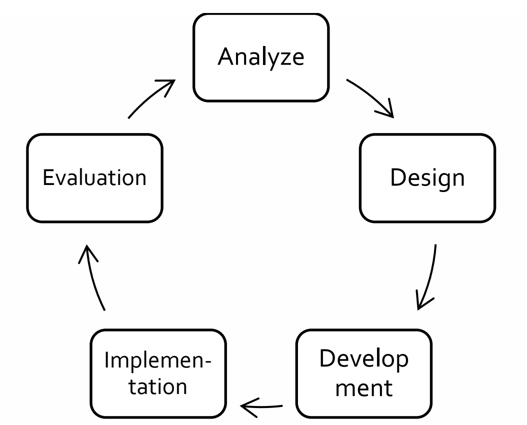

Figure 1. Research process

Analyze. At this stage, various information is collected in full through observation and direct interviews. Information such as needs analysis, curriculum analysis, and media analysis. The needs analysis includes the material, the student's self-assessment, and the learning media used. Curriculum analysis is carried out to determine indicators and learning outcomes. Media analysis was performed to develop the Mathbox application.

Design. At this stage, researchers design the Mathbox application before it is developed through the Codular website. Researchers compile material listed on the Mathbox application and compile research instruments to collect development research data. Research instruments include self-assessment questionnaires, student comprehension tests, and media validation questionnaires.

Development. At this stage, the development process of the Mathbox application is carried out based on the hypothesis design that has been designed, then further developed and programmed as needed, and realized into an Android application product. Academic validators and practitioners test the resulting Mathbox application products. Validation is carried out to measure the feasibility of the product developed by filling out the media validation questionnaire. These assessments are used as guidelines for improving the Mathbox app. Once the Mathbox application is refined based on the results of media validation, it can then be deployed to target learners.

Implementation. At this stage, researchers conducted product trials on four validators to determine the feasibility of Mathbox applications before the applications were applied to students. Then it was tested on class VIII MTs Muhammadiyah 1 Malang students three times by providing pre-test and post-test self-assessment questionnaires and a material understanding test of the Pythagorean theorem to find out student responses about the feasibility and achievement of the Mathbox application in improving self-assessment and student understanding.

Evaluation. At this stage, an evaluation is carried out based on the results of the response questionnaire and student concept understanding tests to determine the quality and feasibility of the Mathbox application.

The technique of collecting data for this research uses a response questionnaire and an understanding test. This study has two response questionnaires; the media validation questionnaire and the self-assessment questionnaire. The media validation questionnaire is addressed to academic and practitioner validators. Self-assessment questionnaires and comprehension tests are intended for students. In the media validation questionnaire using an assessment with the Guttman scale, there are two if "yes" is worth one (1) and if "no" is zero (0) (Saputrama et al., 2022). The results of the media validation are percentages, then analyzed according to the Likert scale score percentage criteria (Sukma & Kholiq, 2021), as in the Table 1.

Table 1. Likert Scale Score Percentage Criteria

Percentage (%)	Criterion
x ≤ 20	Very Less
20 < x ≤ 40	Less
40 < x ≤ 60	Enough
60 < x ≤ 80	Good/Valid
x > 80	Very Good/Very Valid

In the self-assessment questionnaire, students use the Likert scale, with the highest Likert scale score being 4 (Strongly Agree) and the lowest being 1 (Strongly Disagree) (Liliana et al., 2020). The questionnaire results are percentages, then analyzed according to the validation assessment criteria (Saniriati et al., 2021) presented in the Table 2.

Table 2. Validation Assessment Criteria

P value (%)	Percentage Categories
85 < P ≤ 100	Very Good
70 < P ≤ 85	Good
55 < P ≤ 70	Enough
40 < P ≤ 55	Not Good Enough
P ≤ 40	Less Than Once

Students' understanding tests were carried out by providing several problems related to the Pythagorean theorem before and after the Mathbox application was implemented. For student comprehension, test results in the form of pre-test and post-test scores are analyzed using the Paired T-test on the Minitab to determine whether there is an increase in students' understanding of the Pythagorean theorem.

The data analysis technique of this study is descriptive qualitative, which describes the results of the development of the Mathbox application. The response questionnaire and comprehension test data were analyzed using statistical calculations. The results of the assessment and the response from the validator are then searched for the average score to determine the quality and feasibility of the Mathbox application to improve students' self-assessment and understanding of the Pythagorean theorem.

RESULTS AND DISCUSSION

Result

This research uses the ADDIE development model, which consists of 5 stages: analysis, design, development, implementation, and evaluation.

Analysis

The results of the analysis of the development of Codular-based Mathbox media are as follows.

Needs analysis. Needs analysis is carried out based on school observations to find problems related to the learning process. The information obtained is: 1) The number of materials the student must master. The amount of material to be mastered makes students feel depressed for students with low memory and understanding; 2) the student's lack of understanding of the Pythagorean theorem. This is due to the varied understanding of students at the elementary school level; 3) Students still need self-assessment. This is known from the results of an interview with one of the mathematics teachers at MTs Muhammadiyah 1 Malang; 4) The learning conditions used have weaknesses in the unevenness of each student's understanding and require much time for students to understand the material presented. This makes students less confident in learning the Pythagorean theorem. So that learning media is needed that can support and increase students' confidence to be more active in the learning process.

Curriculum analysis. Based on the 2013 revised 2016 curriculum used by MTs Muhammadiyah 1 Malang, curriculum analysis was carried out. The result of this analysis is that there needs to be more emphasis on student self-assessment and understanding, such as practice questions and explanations of the core problems given are still less than learning outcomes and indicators of understanding. Thus, the analysis results impacted students' self-assessment and need for improvement in students' understanding of the Pythagorean theorem material.

Media analysis. Based on the analysis, it was found that the previously used learning media yang has not strengthened students' self-assessment and understanding. Therefore, the Mathbox application was developed based on the results of such analysis. The Codular and Companion websites became the main ingredients used to develop the Mathbox application.

Design

The next stage is the design of the Mathbox application. This application is designed with the development goal of improving student self-assessment and understanding. This goal is realized with complete and explicit material in its application so that students can understand what is learned. For self-assessment, researchers realize this through quizzes that provide feedback points with correct and fast workmanship.

Media reference. In developing the Mathbox application, researchers seek and collect references from various sources. Application display references and images from Freepik.com; moving icon from Lotties; various icon shapes from Svg.repo; background view from Canva; and video material from Youtube. Video material is included in the Mathbox application to help students understand the Pythagorean theorem.

Media design. The design was created as a simple illustration of the Mathbox application. The design of the Mathbox application consists of 1) Initial display. This view contains symbols from the "Mathbox" application and moving icons with a time duration. 2) Display the initial menu. This view contains an image with a math theme and six icon buttons with their respective functions. 3) Display how to use. If the how-to icon is clicked, six ways to use the app will appear and are explained in detail. 4) Display of learning outcomes. This display contains learning outcomes students must achieve when studying the Pythagorean theorem. 5) Profile view. This view contains the application developer profile. 6) Material display. This view contains material from the video and a brief introduction to the Pythagorean theorem. 7) Display of practice questions. It contains several questions students can work on to hone their learning skills. 8) Quiz view. The last display of this application is a Kahoot-assisted quiz. Not only that, but there are also instructions for operating the Kahoot quiz.

Development

At this stage, it is to develop the application according to the design made at the design stage. The media used to develop the Mathbox application is the Codular website. The steps for developing the Mathbox application are to create an application on the Codular website using materials collected individually. For material display, the material is developed in video form to make it easier for students to repeat explanations. Quizzes developed with the help of Kahoot.id will be displayed when students have finished reading and understanding the material. Mathbox application development can be seen in Appendix A.

After being developed and realized into an Android application. The Mathbox application was validated by four validators, of which three validators were from Mathematics Education lecturers at the University of Muhammadiyah Malang, and one validator was from a mathematics teacher MTs Muhammadiyah 1 Malang. After the validation process is complete, the Mathbox application is refined according to the suggestions given to produce a Mathbox application ready to be used for learning media.

Implementation

At the implementation stage, testing applies to the validated and refined Mathbox application. The application trial occurred at MTs Muhammadiyah 1 Malang with class VIII B of 35 students. However, some students still needed to meet several requirements, so as many as 22 students became the research subjects. Testing is carried out by students first downloading the Mathbox application and then students review a little Pythagorean theorem material in the Mathbox application. Then do some questions to determine students' understanding of the Pythagorean theorem material. Finally, students fill out a self-assessment questionnaire to measure their ability to assess themselves. From the several implementations carried out, there was an almost consistent increase at each meeting regarding indicators of understanding the concept, namely writing the general form of the Pythagorean theorem, and using the concept of the Pythagorean theorem in solving problems related to everyday life.

Evaluation

The final stage in the development of the Mathbox application is evaluation.

Validity Analysis. Validity analysis is carried out based on the results of an assessment by validators to determine the feasibility of the Mathbox application developed. The results of the evaluation of the Mathbox application by each validator can be seen in Table 3.

Table 3. Validator Assessment Results (P)

Validator	Σx	Σi	P (%)	Criterion
1	10	11	90,9	Very Good
2	11	11	100	Very Good
3	10	11	90,9	Very Good
4	11	11	100	Very Good
	P Average =		95,45	Very Good

Information: P = Percentage | Σx = Total number of respondents' answers across all items | Σi = Ideal total score per item

Table 3 shows an average percentage of 95.45% in the "Very Good" category, so the Mathbox application is stated to be very good for use as a learning medium. The results of the validity analysis were strengthened by research by Makmuri et al (2021), that at the media validation stage, a percentage of 83.60% was obtained, also classified as the "Very Good" category, so this Android-based learning application was feasible to use.

Self-assessment analysis. This analysis was carried out twice, namely pre-test and post-test to assess students' self-understanding in learning the Pythagorean theorem. Pre-test and post-test self-assessment analyses are based on student questionnaire responses before and after several questions were given. The results of the pre-test self-assessment analysis showed that the average percentage of student response questionnaires was 50.96% with the "Enough" criterion. The results of the post-test self-assessment analysis showed that the average rate of student response questionnaires was 62.06% with the "Good/Valid" measure. The average percentage on the questionnaire has increased, *so* self-assessment by students increases when the Mathbox application has been implemented. These results are by Nugroho (2019) research which shows students' increased self-assessment due to the application of developed learning tools.

Effectiveness Analysis. Based on the results of the effectiveness analysis using the Paired T-Test test on the Minitab, the results of the Paired T-Test output show that p-value = 0,000. If p-value < α, then Ho is rejected. Following Ho's rejection criteria, it can be concluded that there is an improvement between students' scores on the pre-test *and post*-test. Thus, using the Mathbox application as a learning medium on the material of the Pythagorean theorem was declared effective in improving student understanding. This is in line with the research of Anggraeni et al (2021), which shows an increase in average knowledge of concepts and is in the "Medium" category so that the learning media used can improve students' concept comprehension skills. The results of the Paired T-Test can be seen in Figure 2.

Paired T-Test and CI: pre-test; post-test

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
pre-test	22	1,045	0,575	0,123
post-test	22	1,773	0,429	0,091

Estimation for Paired Difference

Mean	StDev	SE Mean	95% CI for μ_difference
-0,727	0,703	0,150	(-1,039; -0,416)

μ_difference: population mean of (pre-test - post-test)

Test

Null hypothesis	H_0: μ_difference = 0
Alternative hypothesis	H_a: μ_difference ≠ 0

T-Value	P-Value
-4,86	0,000

Figure 2. Paired T-Test results

Discussion

The media developed in this study is the Codular website-based Mathbox application. The Codular website was chosen because it provides various easy-to-understand tools and programming code that makes it easier for teachers to create learning media. Generally, making applications difficult in the program code section so that the application can run (Kather et al., 2022), but on the Codular site, programming is quickly done by pairing program code like game puzzles. Apart from making it easier for teachers to program applications, the Codular website also helps students understand the material being taught in the form of learning media.

The Mathbox application developed contains material on the Pythagorean theorem, several practice questions, and quizzes that students can do to hone their comprehension skills. In the Mathbox application, video material is presented to make it easier for students to repeat material explanations. This aligns with Attalina & Irfana (2020), which state that learning media must make it easier for students to understand the material and create real situations. When the application is implemented for students during learning, the Mathbox application gets a positive response from the existence of quizzes in the form of games where the final result has a level of answering questions that are the fastest, the most precise, and the right. In addition to the positive response from students, mathematics teachers at MTs Muhammadiyah 1 Malang also gave their opinions regarding the Mathbox application. The application received an excellent assessment for use as a learning medium in terms of design, language, operation, and materials.

In addition, the Mathbox application

is suitable for students when studying independently because it can be used anywhere and anytime. As a result of students' positive responses, the Mathbox application is an effective and efficient learning medium to help improve student understanding. The development of Codular website-based learning media has also been carried out by researchers before, but what distinguishes this research is the media produced and the purpose of the study. The research of Rizqiyani et al (2022) made an E-Module to improve students' mathematical literacy skills. Research by Rismayanti et al (2022) produced an E-Module to enhance students' mathematical thinking skills.

The advantages of the developed learning media are 1) media development can be done by anyone, including teachers, because of the easy-to-access programming features, 2) students can easily access the Mathbox application using their respective mobile phones, 3) attractive media display designs with matching color combinations, 4) material presented in video form makes it easier for students to repeat material, 5) practice questions in the Mathbox application can hone students' skills in solving various kinds of questions, 6) adding game-based quizzes makes students more interested and challenged to solve questions presented in the quiz, 7) the Mathbox application can be used anywhere and anytime so that it can be used as an independent learning media for students, 8) can improve student self-assessment and understanding.

But running this application requires an internet network to access materials and quizzes, and only Android-based phones can use this application. In addition, the quizzes in the Mathbox application have a limited active period of only one month.

Implications

This research implies that the school or research subjects provide several conditions when conducting research. The requirements are the willingness and agreement between the researcher and the research subject. In addition, this research produces learning media based on Android applications that facilitate the learning process and improve students' self-assessment and understanding of the Pythagorean theorem. This application can also be used in independent learning because it can be accessed anywhere and anytime.

Limitations

The limitations of this research are the circumstances in the school environment of the research subjects, which are challenging to control correctly, the difficulty of managing research time so as not to interfere with ongoing learning time at school, and limited research time. In addition, there is also a limit on the active period of the quiz contained in the learning media. However, this is not an obstacle for researchers because both parties can overcome these limitations well.

CONCLUSION

Based on the research results, the developed Codular website-based Mathbox application proved valid, and practical and could improve students' self-assessment and understanding of the Pythagorean theorem. This can be seen from the Mathbox application, which is supported by video material that allows students to repeat explanations and some practice questions to hone students' skills in understanding the material, as well as quizzes to find out how students understand the Pythagorean theorem has increased.

This application is still limited to the use of the internet network and the active period of the quiz, therefore future researchers are expected to develop better and more innovative learning media, of course with different contexts.

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Appendix

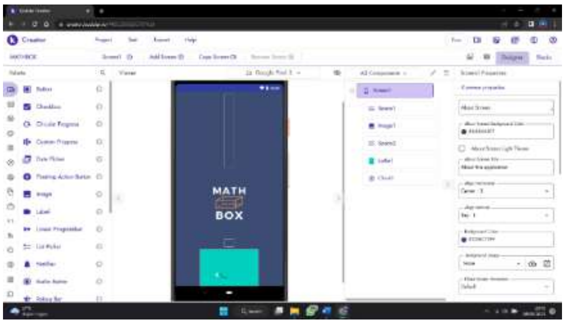

Figure 3. Initial view

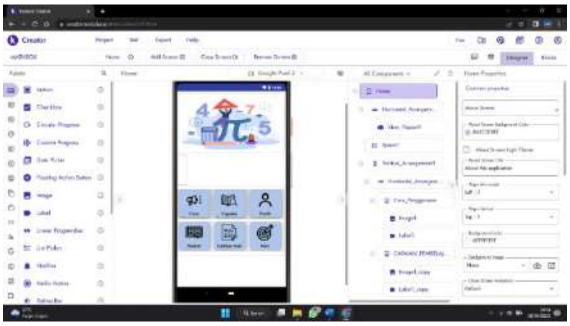
Figure 4. "Home menu" display

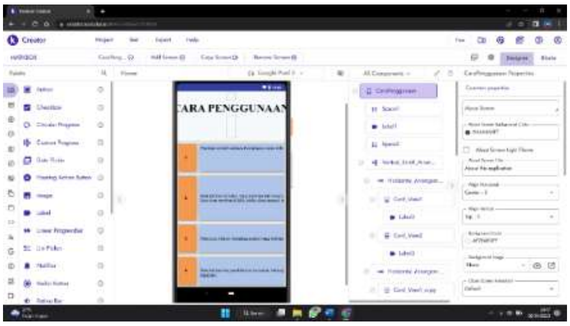

Figure 5. "How to use" view

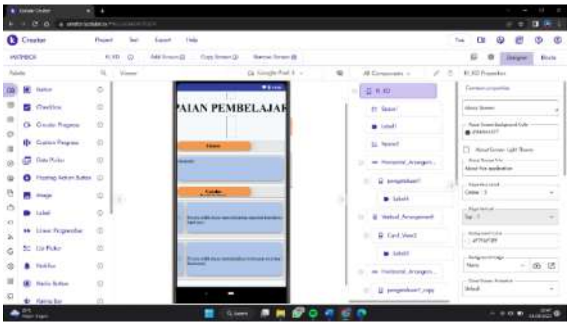

Figure 6. "Learning outcomes" view

Figure 7. "Profile" view

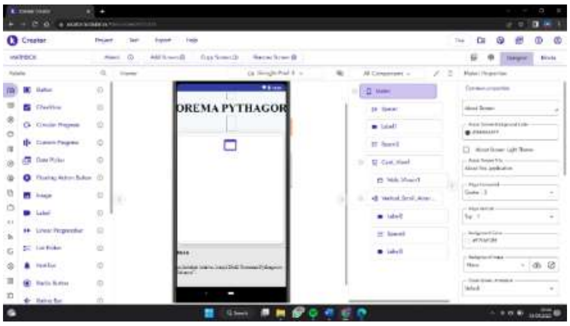

Figure 8. Display of "material"

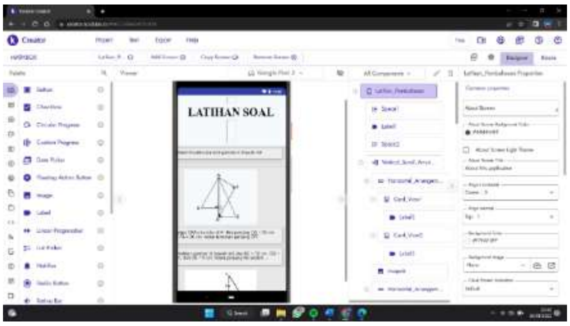

Figure 9. Display of "practice questions"

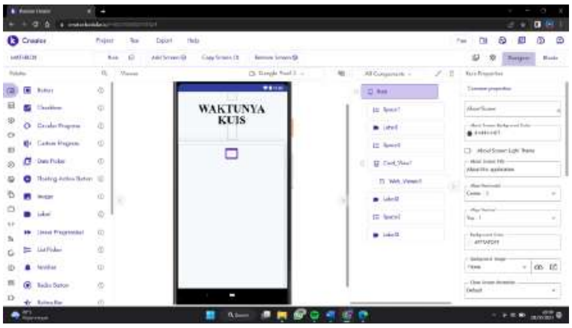

Figure 10. "Quiz" view

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Mathematical Problem Solving in E-Learning Based on David Kolb's Learning Style

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Abstract

This qualitative descriptive research aims to describe mathematical problem-solving ability in e-learning in terms of David Kolb's style study. The research subject was 54 students of Mathematics Education in the sixth semester who took the Vector Analysis course. Data collection techniques used are questionnaires, tests, and interviews. Two students from each learning style were randomly selected. Data obtained from the test results in a description analyzed and described in a narrative based on an indicator of mathematical problem-solving ability. The results showed that the assimilator learning style dominates the other learning styles. The solution of a problem mathematical for a student on the e-learning based on type assimilator learning style can be filled four phases of Polya problem solving maximally. The diverger type can only follow the necessary steps to solve the problems until they execute the strategy. Converger and accommodator types can perform the same four phases of the Polya problem-solving but must be optimized. Further research includes digging up information about learning styles outside of David Kolb and conducting observations and interviews to measure suitability with David Kolb's learning style.

Keywords: Problem-solving; e-learning; David Kolb's learning style

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Abstrak

Penelitian ini adalah penelitian deskriptif kualitatif yang bertujuan untuk mendeskripsikan kemampuan pemecahan masalah matematis pada e- learning berdasarkan dari gaya belajar David Kolb. Subjek penelitian adalah 54 mahasiswa Pendidikan Matematika semester VI yang menempuh mata kuliah Analisis Vektor. Teknik pengumpulan data yang digunakan ialah angket, tes, dan wawancara. Dua mahasiswa dari setiap gaya belajar dipilih secara acak. Data yang diperoleh dari hasil tes berbentuk uraian dianalisis dan dideskripsikan secara narasi berdasarkan indikator kemampuan pemecahan masalah matematis. Hasil penelitian menunjukkan bahwa tipe gaya belajar assimilator mendominasi tipe gaya belajar lainnya. Pemecahan masalah matematis mahasiswa pada e-learning berdasarkan tipe gaya belajar assimilator dapat memenuhi empat tahapan pemecahan masalah Polya secara maksimal. Mahasiswa dengan tipe gaya belajar diverger hanya mampu memenuhi tahapan pemecahan masalah Polya hingga pada melaksanakan strategi. Mahasiswa dengan tipe gaya belajar converger dan accomodator mampu melaksanakan empat tahapan pemecahan masalah Polya namun belum maksimal karena terdapat indikator yang belum terpenuhi. Penelitian lebih lanjut antara lain menggali informasi mengenai gaya belajar diluar David Kolb, melakukan observasi dan wawancara untuk mengukur kesesuaian dengan gaya belajar David Kolb.

INTRODUCTION

Problem-solving is one of the essential cognitive activities used in everyday life. One of the driving factors for a person's success in living his life is determined by his thinking skills, especially problem-solving skills (Zanthy, 2016). There are two types of problems in mathematics: routine and non-routine (Riffyanti & Setiawan, 2017). Non-routine problems are more complex than routine problems because they represent new events that have never been encountered before (Umrana et al., 2019; Riffyanti & Setiawan, 2017). Therefore non-routine problems require a high level of skill in interpreting the solution (Putri, 2018).

Learning about problem-solving is the spearhead of learning mathematics (Arifin et al., 2019; Fransiska et al., 2019; Umrana et al., 2019). Students must have skills in understanding a problem, such as changing the problem they understand into a mathematical model, then solving the problem and interpreting the solution obtained (Hidayat, W., & Sariningsih, 2018). According to Polya, four stages can be used in solving a problem, namely 1) Understanding a problem; 2) Making a plan to solve a problem; 3) Implementing the design, and 4) Re-check the results obtained (Kurniawan et al., 2020; Khusna et al., 2019; Aprianti et al., 2020).

Students must possess problem-solving abilities (Mariam et al., 2019). Through solving problems, students can develop ideas and build new ideas, and form skills in understanding mathematical concepts (Aprianti et al., 2020). In addition, students are also able to see the relationship between mathematics and other sciences (Mariam et al., 2019; Aprianti et al., 2020). However, the case that is often encountered today is that students can only solve the same questions as their lecturers have given them during learning (Putri, 2018; Aprianti et al., 2020). This is motivated by several factors, namely teaching styles and learning models (Oktonawiati et al., 2018; Kurniawan et al., 2020; Aprianti et al., 2020).

The existence of the Covid-19 pandemic caused learning to experience a transition. The Ministry of Education and Culture issued a policy in the form of switching learning methods from face-to-face (offline) to learning that is covered in a network (online) (Ansori & Sari, 2020; Hasrul et al., 2019). Online learning currently challenges educators to continue creating interesting learning to achieve the learning objectives that have been formulated.

E-learning (Electronic Learning) supports the development of information and communication technology to overcome these challenges (Zukhrufurrohmah et al., 2021; Putri, 2018). E-learning is an online platform-based learning model that utilizes information technology such as Zoom, Google Meet, WhatsApp, Blogs, or Websites. (Usman, 2018; Penambaian, 2020; Hasrul et al., 2019). LMS (Learning Management System) is a form of e-learning that students consider attractive (Bringula et al., 2021). E-learning is carried out by greeting students through platforms used in learning, such as LMS, Zoom Meeting, WhatsApp Group, and other applications. After that, the teacher provides instructions regarding lecture material and video links and reviews articles that follow the discussion material (Selfi & Akmal, 2021)

Some literature has shown the positive effect of e-learning from the insights of learners or students (Gautam dan Tiwari, 2016; Chang, 2016). One of them is that e-learning allows students to observe many flexible ways of learning to go to class with a much-reduced need for travel (Rawashdeh et al., 2021; Yuhanna et al., 2020). However, besides these advantages, the absence of essential personal interaction is the most obvious weakness of e-learning, not only among fellow students but also between teachers and students (Rawashdeh et al., 2021). In addition, students will also be addicted to using electronic goods.

In addition to learning models, a learning style is one variable that encourages one's learning progress. Several studies say that there are things that can influence students in accepting mathematics learning, namely learning styles (Khusna et al., 2019; Umrana et al (2019). Learning styles that can facilitate students in the learning process are learning styles of the Kolb model (Suwi et al., 2018; Khusna et al., 2019).

David Kolb emphasized that one's orientation in the learning process is influenced by four tendencies, namely concrete experience (feeling), reflective observation (watching), abstract conceptualization (thinking), and active experimentation (doing). Then from these four tendencies, Kolb formed four combinations of learning styles, namely 1) Converger, which is a combination of thinking and doing tendencies; 2) Divergent, a combination of feeling and watching tendencies; 3) Assimilator, a combination of watching and thinking tendencies, and 4) Accommodator, a combination of doing and feeling tendencies (Khusna et al., 2019; Oktonawiati et al., 2018; Azrai & Sulistianingrum, 2017).

According to several studies that have been conducted, it is proven that David Kolb's learning style influences the process of solving mathematical problems (Khusna et al., 2019). Improved mathematical problem-solving can be generated through e-learning (Rahmawati & Mulbasari, 2020). However, little research has described how students with Converger, Diverger, Assimilator, and Accommodator learning styles solve mathematical problems in e-learning. More analysis related to students' abilities and ways of solving problems in online learning settings needs to be done to gather information in designing a teaching and learning activity so that it can facilitate students during the learning process. Therefore, the formulation of the problem contained in this study is how students' mathematical problem-solving skills in e-learning are based on David Kolb's learning style. This research aims to describe the mathematical problem-solving ability in e-learning based on David Kolb's learning style.

METHOD

This research is a descriptive study with a qualitative approach that aims to describe mathematical problem-solving in e-learning based on David Kolb's learning style. The subjects of this study were 54 semesters VI students of the mathematics education department who took the Vector Analysis course online through the Learning Management System platform, elmu.umm.ac.id, and Zoom Meeting alternately. The stages carried out in this study are presented in Figure 1.

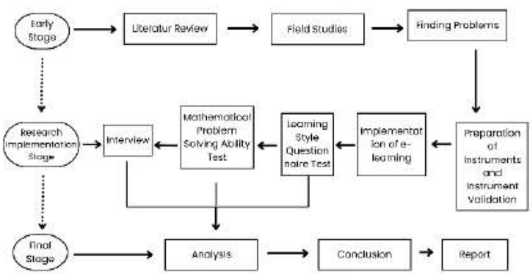

Figure 1. Research Flowchart

The data collection technique used was David Kolb's learning style questionnaire, test questions, and interviews. The questionnaire provided contains "Yes" and "No" answer choices. Furthermore, the test question sheets are in the form of non-routine question types. The instrument used has been declared valid by the validator, a lecturer in charge of the course, and another lecturer with geometry expertise who pays attention to indicators of mathematical problem-solving ability. The interview subjects were randomly selected by two students as representatives of each learning style.

The data obtained from the results of David Kolb's learning style questionnaire were analyzed quantitatively for each tendency that forms a particular learning style, which is classified into 4 (four) types, namely Diverger, Accommodator, Assimilator, and Converger. The four types of learning styles and the tendencies of each type are presented in Figure 2.

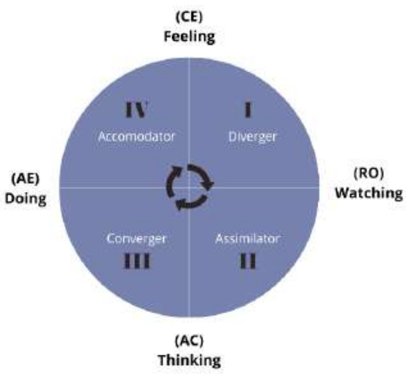

Figure 2. David Kolb's Types of Learning Styles and Domain Predispositions

The results of the work on the test questions were analyzed based on the achievement of the indicators of solving mathematical problems shown in Table 1.

Table 1. Indicators and guidelines for problem-solving assessment

Polya's problem-solving stage	Indicators
Understanding the Problem	Disclose data that is known and ask about the problems found
	Explain the problem in your own sentences
Planning Strategy	Simplify the problem
	Search for sub-goals
	Sort information
Implement Strategy	Interpret the problem in the form of a mathematical sentence
	Implement the strategy during the process and calculations take place.
Check again	Read the question back
	Check all information and calculations.
	Draw conclusions
	Ask yourself if the question has been correctly answered.

RESULTS AND DISCUSSION

Results

Learning in this study was carried out online through the Learning Management System (LMS) platform, elmu.umm.ac.id, and Zoom Meetings alternately. Discussion activities were carried out on the LMS platform and elmu.umm.ac.id. In carrying out this discussion, students were given material and problems regarding the Vector Analysis course. Students who are members of the platform are allowed to ask questions, provide answers, and express opinions (agree/disagree) on the answers or opinions of other friends. Whereas in the implementation of the Zoom Meeting class, the researcher explained the material with the help of a PowerPoint. In this lesson, students are also allowed to ask questions and express opinions. The lesson takes place for a duration of 40 minutes.

Taking research subjects to fill out the David Kolb learning style questionnaire, namely semester VI students of mathematics education at the Faculty of Teacher Training and Education, University of Muhammadiyah Malang, who are taking the Vector Analysis course on July 19, 2021, with a total of 54 students. The questionnaire is filled in individually via the Google form link[1]. David Kolb's learning style questionnaire consists of 40 statements which have been divided into four types of learning style tendencies. The data obtained from the results of David Kolb's learning style questionnaire were analyzed by adding up the "Yes" answers for each type of learning style, namely The Converger type, a combination of thinking and doing tendencies. The Divergent type is a combination of feeling and watching tendencies. Assimilator types are a combination of watching and thinking tendencies. The Accommodator type is a combination of doing and feeling tendencies.

The results of the classification of student learning styles can be seen in Table 2.

Table 2. Result Classification of Learning Styles David Kolb

Learning Style	Number of Students
Assimilator	32
Accommodation	2
Diverger	7
Converger	9
Beyond David Kolb	4

Based on the results of filling out David Kolb's learning style questionnaire on 54 students, it was found that 32 students dominantly entered the assimilator learning style group. Students who are dominant in the accommodator learning style are as many as two. Students who are dominant in the diverger learning style seven are students, and students who are dominant in the converger learning style are nine students. At the same time, the remaining four students cannot be known or are not defined in the various David Kolb learning styles because these students have the identical accumulated scores in the two types of learning styles.

If viewed from the data analysis of David Kolb's learning style questionnaire filling out, most students in the sixth semester of Mathematics Education FKIP Muhammadiyah the University of Malang have the Assimilator type of learning style. This can be proven by the number of students in the assimilator learning style type more than the number of students in the other David Kolb learning style types. Thus, students are more likely to learn through observation, doing, and thinking with various presentations from various sources.

After students are classified into each type of learning style, they are given tests in the form of non-routine descriptions to determine and describe students' mathematical problem-solving. The test will be given on 30 July 2023 through the elmu.umm.ac.id platform after the Zoom Meeting class ends. Then 2 subjects were

[1] https://forms.gle/T1Ah3x2xtqdZfbkg8

randomly selected from each learning style to be analyzed based on indicators of mathematical problem-solving. The results of this analysis were strengthened by the results of interviews conducted by researchers through the Zoom Meeting platform after the subjects completed the test questions.

Discussion

Assimilator Learning Style

In this study, there were two subjects with the codes (MAS1) and (MAS2) who had similarities in answering the questions, so the researcher only wrote down the test answers from subject MAS1. Test question number 1 is presented in Figure 3. The results of the MAS_1 written test on question number 1 is presented in Figure 4.

Based on David Kolb's learning style theory, the assimilator type learning style is a learning style based on abstract conceptualization (AC) and reflective observation (RO) or, in other words, a combination of thinking and observation (Oktonawiati et al., 2018). This allows students with the type of assimilator learning style to understand the concepts of the problems given. In Figure 3, with numbering 1, it can be seen that MAS_1 can understand the problem by disclosing known data and asking about the problems found. Based on the interview, MAS_1 can also express these problems using his own words. Through the abstract conceptualization (AC) stage, students with the assimilator learning style type can act in a structured manner and develop an idea and theory to solve a problem (Mahayukti et al., 2021). In Figure 4 with number 2, MAS_1 can simplify problems, find subgoals, and sort information.

Students with the assimilator learning style type can manipulate abstract things, such as symbols contained in mathematics (Mahayukti et al., 2021). This interest is motivated by the learning process of assimilator students at the abstract conceptualization stage. So that in this study, students with the type of assimilator learning style could interpret problems in the form of mathematical sentences. The truth of this statement is supported by Figure 4. In addition, learning that goes through the abstract conceptualization stage makes assimilator students careful in analyzing an idea they find so that the subject can carry out strategies during the calculation process. The learning process that goes through the reflective observation stage allows students with the assimilator learning style to reflect on what has been understood, planned, and implemented in solving a problem. So, in Figure 4, with numbering 3, it can be seen that MAS_1 can write the conclusions correctly.

The results of this study are relevant to research from Hanalia (2017), which states that students with the assimilator learning style type can solve problems with the four stages of Polya problem solving, namely understanding the problem, planning strategies, implementing strategies, and re-examining. Research conducted by Kablan & Uğur (2021) also states that students with an assimilator learning style in solving non-routine math problems are more successful than other types of David Kolb's learning styles. However, both of them contradict the results of other studies, which state that students with the assimilator type of learning style are only able to solve problems up to the planning strategy stage (Ratnaningsih et al., 2019; Rokhima et al., 2019).

Diverger Learning Styles

The divergent learning style is a learning style based on concrete experience (CE) and reflective observation (RO) or, in other words, a combination of feelings and observations (Oktonawiati et al., 2018). The results of the MD_1 written test on question number 1 is presented in Figure 5.

Figure 5, with numbering one, shows that MD_1 can understand the problem by expressing known and asked data from the problems found and being able to explain in his own words. Based on the interview, MD_1 had found almost the same questions before, so he did not find it difficult to understand the problem. This is in line with (Soraya et al., 2020) that students who learn through the concrete experience (CE) stage tend to reflect on the experiences they have experienced. It also affects MD_1 in planning strategy. So, if viewed based on Figure 5 with numbering two and the interviews conducted in this study, students with a divergent learning style type can simplify a problem, find sub-goals, and sort information correctly.

According to Hanalia (2017), students with divergent learning style types learn through the reflective observation stage, where at this stage the divergent students will focus on understanding the meaning of mathematical ideas. In Figure 5 with number 2, it can be seen that MD_1 can interpret the problem in the form of a mathematical sentence. However, in this study, MD_1 has yet to be able to fulfill the indicators of carrying out the strategy optimally because it experienced a calculation error. This error can be seen in Figure 5 with number 4, where $\int(-e^{-t}-1)dt$ should be $\left(\frac{1}{e^t}-t+C\right)$, but MD_1 gets the result (e^t-1+C). So that MD_1 gets the wrong solution or answer.

Based on the interview, MD_1 felt confused about finding the value of e and was unable to reduce the integral, so during the calculation process, and concluding there were errors. In addition, MD_1 also feels that there needs to be more time to re-examine the problem-solving that has been done. This research is relevant to Eko et al. (2016) and Rokhima et al. (2019), who state that divergent students need more time to fulfill the re-examination indicator.

Converger Learning Styles

There are two subjects, namely with codes (MC1) and (MC2) which have similarities in answering tests of mathematical problem-solving abilities. The results of the MC_1 written test on question number 1 is presented in Figure 6.

The converger type learning style is a learning style based on abstract conceptualization (AC) and active experimentation (AE) or in other words a combination of thinking and acting (Soraya et al., 2020). This allows students with a converger learning style to gain a conceptual understanding of the problems given. Figure 6 with numbering 1 represents an understanding of the MC_1 problem by disclosing the known data and what questions is given to the problems found and being able to convey them using their sentences.

In Figure 6 with number 2 (see appendix), MC_1 can search for sub-goals and sort information. Supported by the results of the interviews that have been conducted, MC_1 is also able to simplify the problems found. So students with a converger learning style are able to make conceptual and structured plans. This is in line with (Mahayukti et al., 2021), who state that through the abstract conceptualization (AC) and active experimentation (AE) stages, students with the converger learning style type can act in a structured manner and are capable of developing an idea and theory to complete a problem. However, the search for the right sub-goals did not make MC_1 able to execute the strategy well. Searching for the value of A in Figure 6 with numbering four should yield the result $\left(\frac{3}{2}-\frac{1}{4e^2}\right)$, while the result of the MC_1 calculation is $A=\frac{1}{2}-\frac{1}{4e^2}$.

According to Wicaksono et al., (2021), this was because students needed to be more careful in the calculation process. Hence, they experienced errors or did not lead to the correct solution, unlike the test results in question number 2. In the results of test number 2, MC_1 has yet to fully fulfill the stages of planning a strategy. Test question number 2 is presented in Figure 7. Whereas in Figure 8, the rectangle is marked with a red border, it can be seen that MC_1 cannot fulfill the indicator of finding sub-objectives. The first sub-goal to be sought in problem number 2 is to find $\vec{F}(t)$, substituting $t=0$ or $t=90$ to $\vec{F}(t)$. Meanwhile, MC_1 directly substitutes the example $t=0$ to $\vec{r}(t)$.

When viewed from the results of the interviews, MC_1 felt that he had never found a similar problem, so he had difficulty finding sub-objectives to solve the problem. This is in line with the research results of Ratnaningsih et al., (2019) which state that students with a convergent learning style are still not optimal in the strategy planning stage. According to Mahayukti et al., (2021), this was motivated by a lack of understanding of the concept and a lack of examples and exercises of similar questions. In this study, students with a converger learning style wrote inaccurate conclusions. This was because the two subjects needed help in carrying out the previous stage (Eko et al., 2016).

Accommodator Learning Styles

There are two subjects, namely with the codes (MAC1) and (MAC2) which have similarities in answering tests of mathematical problem-solving ability, so the researcher only writes down the test answers from subject MAC_1. The results of the MAC_1 written test on question number 1 is presented in Figure 9.

The accommodator-type learning style is a learning style based on concrete experience (CE) and active experimentation (AE) or, in other words, a combination of feelings and actions (Oktonawiati et al., 2018). So in Figure 9, with numbering one and the results of the interviews conducted, MAC_1 can reveal known and asked data from the problems found and able to explain in their sentences. In addition, MAC_1 is also able to plan strategies by finding sub-goals, sorting information, and simplifying problems. This statement is represented in Figure 9 with numbering 2. However, in implementing the strategy, MAC_1 is only able to interpret the problem in the form of a mathematical sentence because MAC_1 makes a calculation error.

The error shown in Figure 9 (see appendix) is four circled in red, which should result from $\int(e^{-2t})dt=-(2e^{2t})^{-1}$. Based on the interviews, subjects with the accommodator learning style type are in a hurry to re-examine the results of the calculations and have yet to understand the concept fully. So the results of this study are relevant to Ratnaningsih et al. (2019), who state that students with the accommodator learning style type can do calculations, but there are still errors. This is due to a need for examples in working on similar questions (Mahayuktietal., 2021). Other research that is in line with this research also states that students with the accommodator learning style type make mistakes in calculations and do not double-check (Winarso & Toheri, 2021)

If viewed from the data obtained, students with the accommodator learning style type can only carry out indicators, check all information and calculations, and ask themselves whether the questions have been answered correctly. So this research is relevant to Hanalia (2017), who states that accommodator students have yet to be able to carry out the re-examination stage fully. In line with that, other studies also state that students with the accommodator type of learning style are unlikely to reach the re-examining stage (Ratnaningsih et al., 2019).

Research Findings

According to previous research, students with the assimilator learning style type have yet to be able to reflect optimally on Polya's problem-solving process due to limited time to solve problems (Apiati & Hermanto, 2020). However, based on the results of this study, students with the assimilator learning style could solve problems using the four stages of Polya problem solving, namely understanding the problem, planning a strategy, implementing the strategy, and checking again. The results of this study are relevant to other research, which states that students with the assimilator learning style type can fulfill all indicators in Polya problem-solving (Widyaningsih & Chasanah, 2020).
However, based on the results of this study, students with the assimilator learning style could solve problems using the four stages of Polya problem solving, namely understanding the problem, planning a strategy, implementing the strategy, and checking again. The results of this study are relevant to other research, which states that students with the assimilator learning style type can fulfill all indicators in solving Polya problems.

Implications

Further research related to solving mathematical problems in e-learning includes (1) Extracting information about learning styles that are beyond David Kolb's learning style, (2) Observation of student learning styles that encourages the truth of learning styles in each student, (3) Conduct further interviews to measure suitability with David Kolb's learning style.

Limitations

The limitation of this study is the need for more references regarding the elaboration of learning styles outside of David Kolb, so researchers have not been able to describe the learning styles outside of David Kolb fully. In addition, the observations made by researchers were only through online learning. So, the limitations of these places make researchers unable to observe optimally to encourage the truth of learning styles in each student.

CONCLUSION

Solving students' mathematical problems in e-learning based on the type of assimilator learning style can fulfill the four stages of Polya's problem-solving. Students with the type of divergent learning styles are only able to fulfill the Polya problem-solving stages up to implementing strategies. Students with converger and accommodator learning styles can carry out the four stages of solving the Polya problem but are not optimal because there are indicators from several stages that still need to be fulfilled.

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Appendix

1. Diketahui percepatan vektor fungsi didefinisikan dengan $e^{-2t}\hat{\imath} + e^{-t}\hat{\jmath}$. Vektor kelajuan dari vektor fungsi tersebut ketika $t = 0$ adalah $< -1, -2, 1 >$, sedangkan vektor fungsi ketika $t = 1$ adalah vektor $\hat{\imath} - \hat{k}$. Tentukan vektor fungsi tersebut.

Figure 3. Test Question Number 1

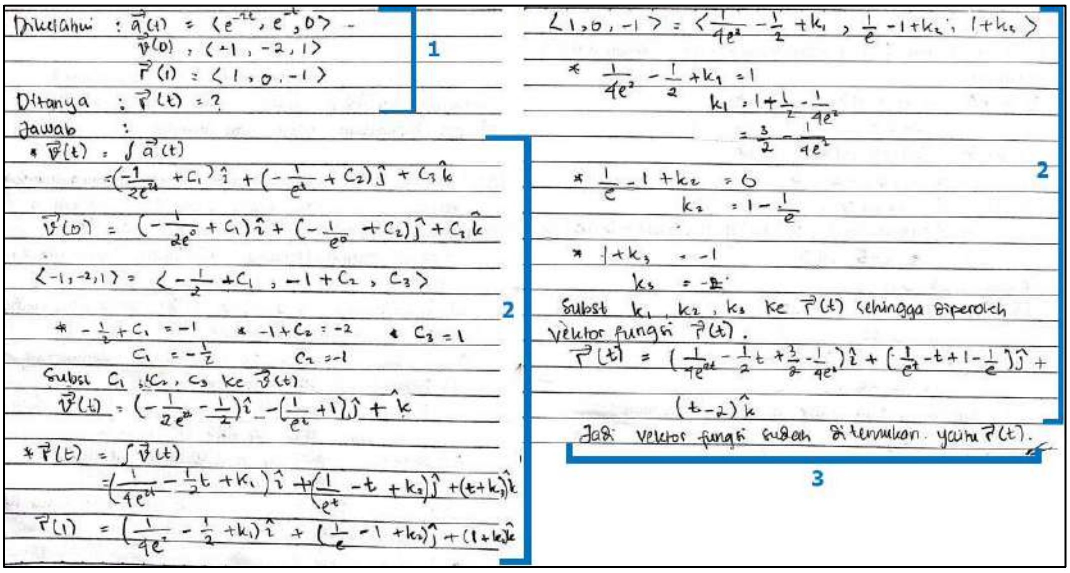

Figure 4. MAS_1's Written Test Result at Problem Number 1

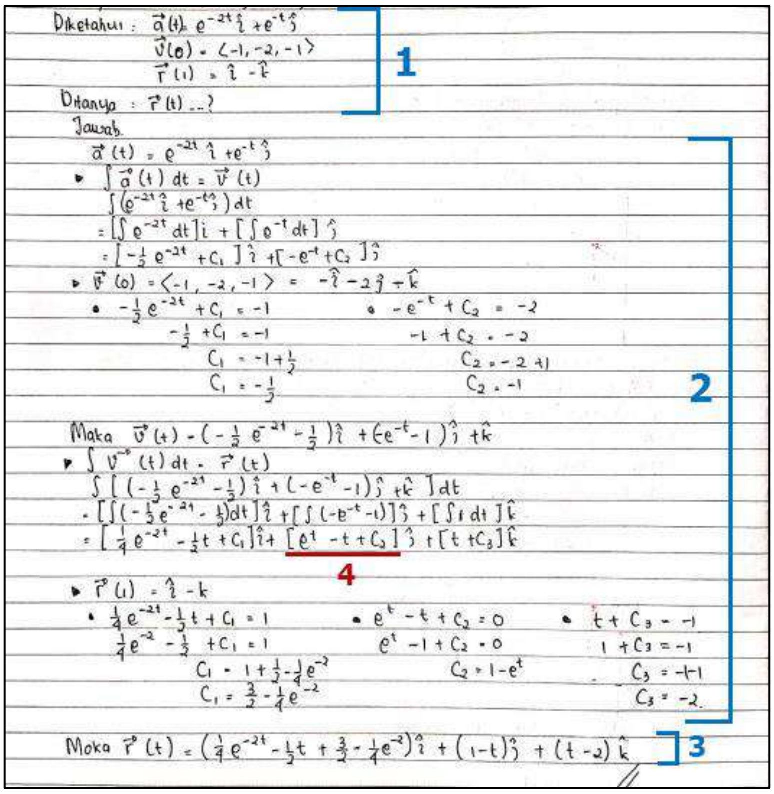

Figure 5. MD_1's Written Test Result at Problem Number 1

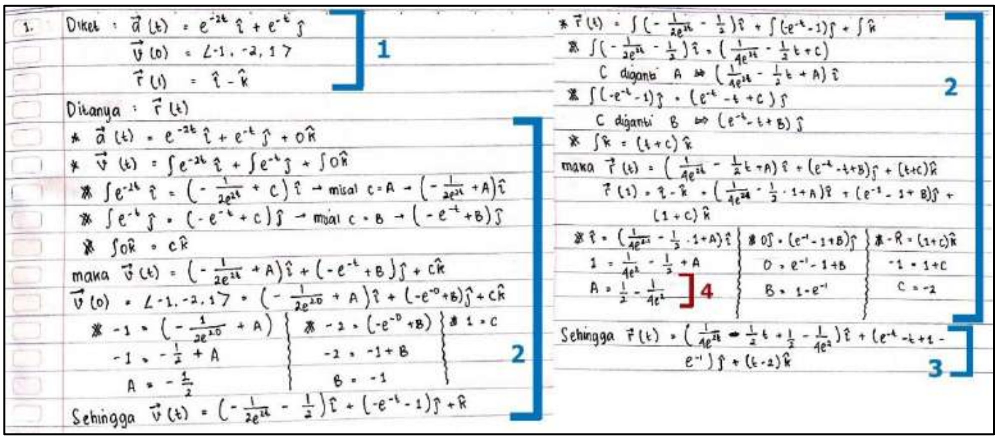

Figure 6. MC_1's Written Test Result at Problem Number 1

2. Sketch the vector function $\vec{r}(t) = 2\cos t\,\hat{\imath} + 2\sin t\,\hat{\jmath}$, then find the tangent vector at $t = \frac{5\pi}{6}$ and sketch that tangent vector.

Figure 7. Test Question Number 2

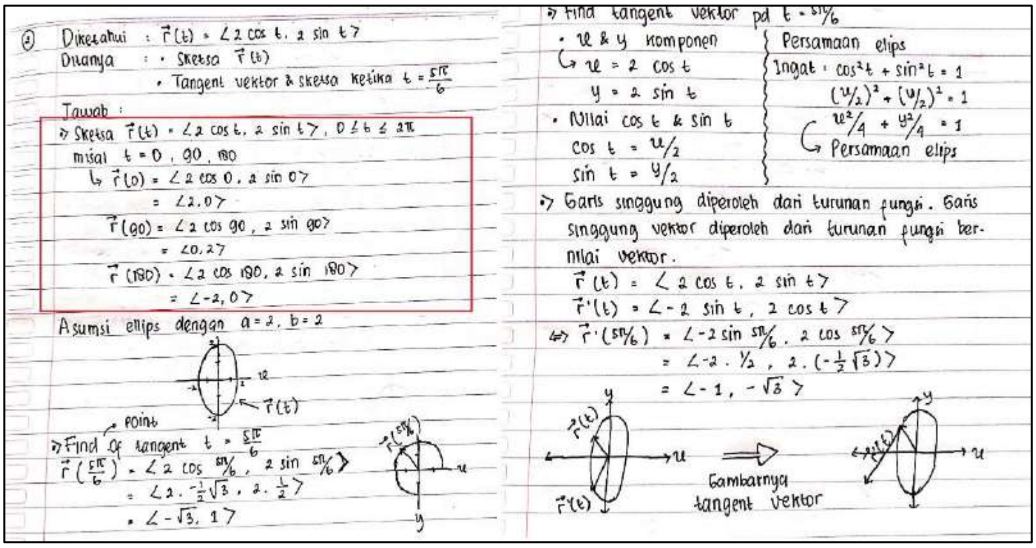

Figure 8. MC_1's Written Test Result at Problem Number 2

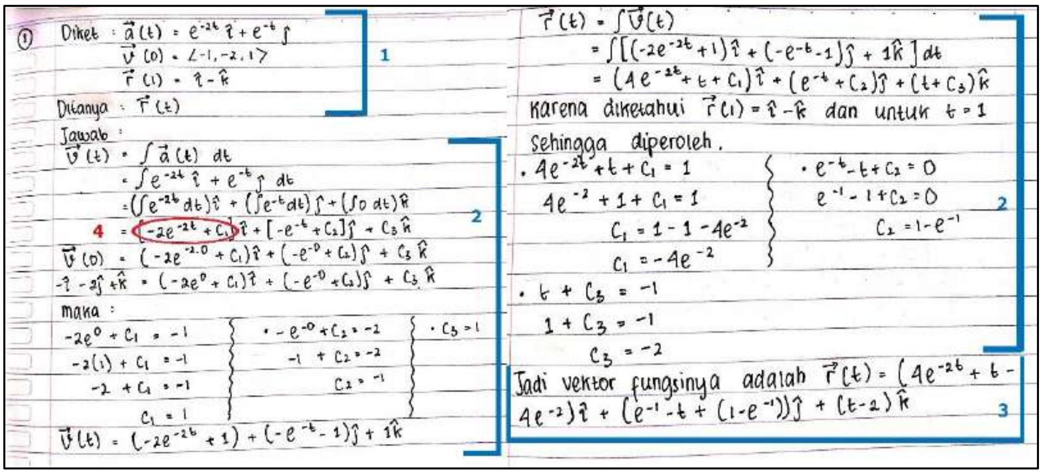

Figure 9. MAC_1's Written Test Result at Problem Number1

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Development of HoTS-Based Elementary Linear Algebra Course Test Instruments Charged with Islamic Character

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Abstract

This test is known as an evaluation tool or test instrument in the form of questions that are prepared in accordance with learning indicators. A lecturer should be able to provide questions that can trigger students to think at a higher level so that they can be more optimal in achieving learning objectives. This study aims to produce HOTS-based test instruments with Islamic characters by looking at the development procedures and quality of HOTS-based test instruments with Islamic characters developed. The type of development used is research research and development (R&D), namely the development of test instruments for linear algebra courses. The development model used is a formative research (Tessmer) model which goes through 4 stages, namely preliminary, self-evaluation, prototyping (expert review, one to one, small group), and field test. The test subjects in this study were students of mathematics education class PMAT B, Faculty of Tarbiyah and Teacher Training, UIN Alauddin Makassar with a total of 33 students. Based on the results of the trials conducted, it was obtained that: (1) the test instrument was declared "valid" with a very suitable category, the test instrument was declared reliable with a very high category (reliable), the test instrument had a fairly good difficulty level with a moderate category, the test instrument had a good distinguishing power with a good category. Thus, the test instruments of the HOTS-based elementary linear algebra course with Islamic characters are of good quality. Therefore, HOTS-based test instruments with Islamic characters can be used as evaluation tools in the form of exercises, quizzes, and semester exams to measure students' higher order thinking skills.

Keywords: *Development Instrument Test, HOTS, Character Islamic, Elementary Linear Algebra*

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Abstrak

Tes ini dikenal dengan istilah alat evaluasi atau instrumen tes berupa soal-soal yang disusun sesuai dengan indikator pembelajaran. Seorang dosen hendaknya mampu memberikan soal-soal yang dapat memicu mahasiswa untuk berpikir tingkat tinggi agar dapat lebih optimal dalam mencapai tujuan pembelajaran. Penelitian ini bertujuan menghasilkan instrumen tes berbasis HOTS bermuatan karakter islami dengan melihat prosedur pengembangan dan kualitas instrumen tes berbasis HOTS bermuatan karakter islami yang dikembangkan. Jenis pengembangan yang digunakan ada-lah penelitian research and development (R&D) yaitu pengembangan instrumen tes mata kuliah aljabar linear. Model pengembangan yang digunakan adalah model formative research (Tessmer) yang melalui 4 tahap yaitu preliminary, *self evaluation, prototyping (expert review, one to one, small group), dan field test*. Subjek uji coba pada penelitian ini adalah mahasiswa pendidikan matematika kelas PMAT B, Fakultas Tarbiyah dan Keguruan, UIN Alauddin Makassar dengan jumlah 33 mahasiswa. Berdasarkan hasil uji coba yang dilakukan, diperoleh bahwa: (1) instrumen tes dinyatakan "valid" dengan kategori sangat sesuai, instrumen tes dinyatakan reliabel dengan kategori sangat tinggi (reliabel), instrumen tes memiliki tingkat kesukaran yang cukup baik dengan kategori sedang, instrumen tes memiliki daya pembeda yang baik dengan kategori baik. Dengan demikian, instrumen tes mata kuliah aljabar linear elementer berbasis HOTS bermuatan karakter islami memiliki kualitas yang baik. Oleh karena itu, Instrumen tes berbasis HOTS bermuatan karakter islami dapat digunakan sebagai alat evaluasi berupa latihan, kuis, dan ujian semester untuk mengukur kemampuan berpikir tingkat tinggi mahasiswa.

INTRODUCTION

Every activity that has been carried out requires an evaluation process in it. Evaluation is the activity of assessing the state of an object using instruments (Thoha, 2003). Evaluation activities are not just assessing, but an activity that is systematic and directed based on goals. To determine the value of the object being evaluated it is necessary to make measurements, and the form of such measurements is testing.

Evaluation in the world of education is better known as learning evaluation or evaluation of learning outcomes. There are three main reasons why education requires an evaluation process (Thoha, 2003). First, the purpose of education directs how the teaching and learning process should be carried out, and through evaluation it can be known whether the educational objectives have been achieved properly. Second, conducting learning outcome evaluation activities is one of the characteristics of professional educators. Third, when viewed from an institutional approach, education is a management activity that includes planning, programming, drafting, movement (actuating), control, and evaluation activities. If one of these management functions is not carried out, it can be ascertained that there are institutional deviations, so that the goal will not be achieved. Therefore, evaluation is indispensable in the world of education.

Evaluation of learning in education aims to find out the abilities of students (Ahmad, 2015). In higher education, students are better known as students and educators are lecturers, so that the evaluation of learning outcomes in higher education is used to measure student abilities and find out the success of lecturers in teaching. This form of testing to assess the magnitude of a person's abilities is called a test (Arifah & Yustisianisa, 2012). This test is known as an evaluation tool or test instrument in the form of questions that are arranged according to learning indicators.

A lecturer should be able to provide questions that can trigger students to think at a high level to be more optimal in achieving learning goals. This is because the ability to think can affect a person's level of material mastery. Low student thinking ability triggers difficulties in mastering the material obtained (Andriyani & Yenni, 2019).

Based on the results of pisa (Program for International Students Assessment) 2018 research, the average score of Indonesian students is 379 out of 489 average scores (OECD, 2018) and Indonesia is in 71st position out of 78 participating countries (Faridah et al., 2018). This shows that the performance of Indonesian students is still relatively low. The reason is that Indonesian students are not used to doing HOTS-based questions (Nizar dkk., 2018). Therefore, compiling questions that trigger for higher-level thinking is the right effort to improve the performance of Indonesian students.

Higher Order Thinking Skills (HOTS) is the ability to process information by thinking critically, evaluating, and solving a problem (Kenedi, 2018; Rahmawatiningrum, Kusmayadi, & Fitriana, 2019). Mathematics is one of those lessons that requires a person to think at a high level (Mazana, Montero, Casmir, 2019; Büchele & Feudel, 2022). As Windia Hadi and Ayu Faradillah said in their research, that "A high level thinking ability is a basic ability that must be developed in mathematics learning". That is, the ability to think at a higher level is a basic ability that must be developed in mathematics learning (Hadi & Faradillah, 2019).

Before carrying out evaluation activities, it is necessary to establish material as a basis for developing test instruments. Elementary linear algebra is one of the mathematics courses whose material is very much loved by students. Students' love for elementary linear algebra materials shows a positive attitude, as can be seen from the results of calculating the student's positive attitude score is greater than a neutral attitude (Simanjuntak, 2016). Although there are still students who are not happy with the course. Elementary linear algebra is also the basis for mastery of other higher-level courses (Apriyani, 2015). This means that success in mastering the material in elementary linear algebra courses can make it easier for students to study other courses.

Instruments of elementary linear algebra courses are needed to trigger students to think at a high level. The same thing was obtained by the researcher from the results of his interview with students of the mathematics education study program, UIN Alauddin Makassar. "Students really need questions that can train their thinking skills, especially prospective teachers," said Afifa, a 4th semester student who has gone through linear algebra courses. In addition, her study partner, Diah Nadila, explained the reality that occurs that the elementary linear algebra questions given by the lecturer are only based on existing textbooks or modules, usually the questions are in the form of fills and descriptions. Based on the reality obtained by researchers, the solution offered is to create an instrument based on HOTS.

In addition to improving cognitive abilities, learning mathematics is also expected to be one of the means for achieving predetermined educational goals, namely changes in the attitudes and behaviour levels of students which include religious awareness or in other words, through learning mathematics can be instilled religious values in children (Salafudin, 2015). To achieve this, a lecturer must be able to implement mathematics learning with the insertion of Islamic Academic Culture to achieve attitude competence in accordance with Islamic teachings (Maharani, 2012). Therefore, to achieve these two things in this study, a test instrument that contains Islamic values to form a good personality needs to be developed. As a Muslim, students who are in Islamic universities should get a stimulus of Islamic values in every learning. As expressed in a word that "science without religion is blind and religion without science is limping" so that both must be the basis of any learning (Maarif, 2015).

Based on this, the researcher intends to develop a HOTS-based test instrument with Islamic character. This not only trains students to think at a high level but can also have a positive impact in the form of instilling Islamic values in students. Students as the next generation should be accustomed to doing questions that trigger to think high-level and get stimulus to strengthen their character. Because this habit can be a provision for these students when taking on roles in the future. The test instruments developed are in the form of questions that can be used as practice assessments and quizzes.

This research is very important to be carried out to assist lecturers in developing HOTS-based test instruments with Islamic character that are in accordance with learning objectives and produce valid, reliable, practical, and effective evaluation results. The results of this study can be used as an evaluation tool that has a positive impact on students.

Based on the description above about the importance of HOTS-based test instruments and Islamic character-charged as a tool for evaluating learning outcomes, the researcher will conduct a research "Development of HOTS-Based Elementary Linear Algebra Course Test Instruments Charged with Islamic Characters".

Research And Development

Research and Development (Research and development) is a type of research used to produce a product that has good quality. Developing a product can take the form of updating an existing product or creating a new product (which has never existed before) so that the development does not only develop a product (Sugiyono, 2016). Therefore, development research is a research method whose final result will produce a product that is beneficial to its users.

Tessmer Development Model

Tessmer's formative research type development model consists of four stages, namely the preliminary stage, the self-evaluation stage, the formative evaluation stage (prototyping) which includes expert reviews, one-to-one, and small groups, as well as the field test stage (Jurnaidi & Zulkardi, 2013). The preliminary stage is the stage of collecting references relevant to the research. After obtaining information from these references, the place and subject of the research trial are determined. The self-evaluation stage is divided into two stages, namely the analysis stage and the design stage. The products created and developed will be evaluated by 3 groups at the prototyping stage, namely Expert review, One-to-one, and Small group. The revision results of the Expert review and One-to-one are called prototype II, while the revision results of the Small group group are referred to as prototype III. Furthermore, at the field test stage, field trials of products that have been developed and have been revised will be carried out.

Test Instruments

A typical technique for conducting an evaluation or assessment is to give a test (Yoong, 2015). In general, a test can be interpreted as a tool for measuring the mastery of a measuring object against a certain set of content (Ahmad, 2015). Test instruments are one of the tools used to detect the abilities of learners. The test is a collection of questions to be answered, tasks to be done, and questions to choose from (Sa'idah et al., 2019). Test, measurement, and evaluation are concepts used in education to explain how the progress of learning and the final learning outcomes of students are assessed (Adom, Mensah, & Dake, 2020)

Hots (Higher Order Thinking Skills)

HOTS (Higher Order Thinking Skills) or higher order thinking abilities are a type of non-algorithmic thinking (analytical, evaluative, and creative thinking) that involves metacognition (Hadi & Faradillah, 2019). HOTS is a thought process that involves the mental in an effort to explore complex, reflective and creative experiences that are carried out consciously in achieving goals, namely obtaining knowledge that includes levels of analytical, synthesis, and evaluative thinking (Hidayat et al., 2020). HOTS is defined by critical, logical, reflective, metacognitive, and creative thinking (Ramadhan et al., 2019). HOTS can train learners in connecting their ideas or ideas and expand their thinking beyond just remembering the information obtained (Kenedi, 2018).

Islam of Character

Islamic character is human attitudes, deeds, or behaviors based on the Qur'an and hadith. Islam teaches that reason is not the only tool used to study, but it requires the demands of a holy heart (Akil, 2018). Strengthening islamic character in students should be considered to give birth to a heart that is free from darkening rust. This is so that the student's journey in gaining knowledge can be useful properly. Because through strengthening character education, it can shape human dispositions to be better.

Elementary Linear Algebra

Algebra is a part of mathematics that studies the relationships and properties of numbers using common symbols, for example x,y, and z in algebraic equations. The symbols are used to shorten the writing of the problem in the question. Elementary linear algebra is a subject that has variables, constants, and coefficients that concern including the material of linear equation systems, matrices, determinants, vector spaces, linear transformations, and multiplication spaces in (Dwiputra & Pujiyanta, 2014).

METHOD

The type of research used in this research is development research (Research and Development). Research and Development with Tessmer's development model. Tessmer's formative research type development model consists of the preliminary stage, self-evaluation stage, formative evaluation (prototyping) stage which includes expert reviews, one-to-one, and small groups, as well as the field test stage (field trials). Tessmer's formative research development model was chosen because the steps used are clearer and systematic. This development model will produce better test instruments than other development models because at the self-evaluation stage there are several stages that are not found in other development models, namely: curriculum, learners, and material analysis. Then in this development model there are three trials, this is also not done in other development models, the trials are expert review, one-to-one, and small group to produce pro-totype III which will then be tested in the field so that the resulting test is valid and reliable. In addition, the Tessmer development model is more commonly used for the development of assessment instruments. The following is the research procedure:

Preliminary Stage

At this stage the researcher collects references that are relevant to this research.

After obtaining information from these references, the place and subject of the research trial were determined.

Self Evaluation Stage

This stage is carried out by the researcher himself on the linear algebra instrument that will be developed by the researcher. This stage is divided into two stages, namely:

Analysis stage

At this stage the researchers analyzed the curriculum, students, and materials. In the curriculum analysis, researchers conducted a review of the learning curriculum at the university where the research took place. Furthermore, in the analysis in the student analysis, the researcher collected information about the number of students and the characteristics of the students. In the material analysis, the researcher traces, compiles, and details the main materials that students will learn according to the curriculum that has been analyzed.

Design Stage

At this stage, researchers designed, compiled, and developed HOTS-based linear algebra course instruments with Islamic characters. The researchers designed the grids and test instruments along with the answer keys and scoring guidelines. The results of this product design focus on two characteristics, namely religion and material.

Prototyping Stage

This stage is the validation, evaluation, and revision stage. The instruments created and developed will be evaluated by 3 groups, namely Expert review, One-to-one, and Small group whose results will be used as revision material.

Expert Review

Expert Review is input from experts to improve instruments and products. At this stage the validity test is carried out by experts. They will provide an assessment of the instrument provided by the researcher. The assessment is accompanied by responses and suggestions written on the vali-dation sheet and then used as revision material. The assessment is also used as material to determine whether the product design is valid or not.

Students (One-to-one)

At this stage, the researcher asked 3 students as testers to answer the HOTS-based instrument with Islamic characters that had been developed by the researcher. The three students have high, medium, and low ability levels. After answering the test instrument, students will be asked to comment on the questions they have answered, such as the difficulty level of the questions, the clarity of the learning indicators, and the ease of use of the product. The comments are then used as revision material.

Small Group

The results of the expert review and one-to-one revisions (Prototype II) will be used as a small group trial. At this small group stage, there are 6 students, namely 2 people with high abilities, 2 people with moderate abilities, and 2 people with low abilities. The information that will be obtained from this stage is whether the students can solve the problem in a rationally efficient time, whether the students can use the product easily, whether the problem is too difficult, and whether the product is interesting or vice versa.

Field Test Stage

At this stage, a virtual field test will be conducted using the developed and revised instrument products. This stage will be tested on research subjects.

Trial Design

The design of the HOTS-based instrument trial with Islamic character is in the form of story problems on linear algebra course material. The trial design image based on Tessmer's formative research type development model can be seen below.

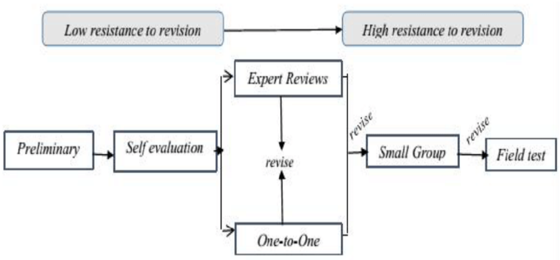

Figure 1. Trial design

The test design of this formative research development model starts from a low level of resistance to the revision process, namely the preliminary stage, collecting information relevant to this research. Then, to the self-evaluation stage to analyze and design the product. Next, to a higher level of resistance, namely the prototyping stage. At this stage, the questions developed will be validated by several validators and tested on three students. The results of this prototype question are used as evaluation material for revision. After revision, the question was tested again in a small group or small group and then revised again. When the validation results from the experts' state that the questions are valid, they are ready to be used in the field test stage or field test to the research subjects.

Test Subjects

The test subjects of the HOTS-based linear algebra course instrument development products containing Islamic characters were second semester students of mathematics education study program class B, Faculty of Tarbiyah and Keguruan, UIN Alauddin Makassar who took linear algebra courses and numbered 33 people.

Research Instrument

Research instruments are measuring instruments in the research process to collect data in a study. The instruments in this study were test instruments, test instrument validation sheets, response questionnaires, and observation sheets.

Data Analysis Technique

The data analysis technique in this research is the analysis of the content validity of the questions. **1)** The analysis of the content validity of the questions was carried out to determine the suitability of the questions with the meaning used as the basis for making the questions. The content validity test used is the Content Validity Ratio (CVR). According to Lawshe, CVR is a content validity analysis approach to measure the degree of agreement of experts regarding the suitability of question items with the material (Hendryadi, 2017). To calculate the CVR, the following formula was used (Bashooir & Supahar, 2018)

$$CVR = \frac{2ne}{N} - 1$$

Description: ne = The number of expert reviews that state valid; N = Number of expert reviews who conducted the assessment

Based on the CVR results, it can be determined which questions are accepted in the development of HOTS-based test instruments with Islamic characters. Where the question is declared valid if it has CVR ≥0.99. After the CVR calculation, then the overall validity value of the question can be determined using the CVI (Content Validity Index) with the following formula (Bashooir & Supahar, 2018)

$$CVI = \frac{\sum CVR}{The\ number\ of\ problems}$$

The category of the results of the CVI calculation is in the form of numbers 0-1 which can be categorized as follows (Kristiani et al., 2017).

Table 1. Categories of CVI Calculation Results

Assessment	Criteria
$0 - 0.33$	Not suitable
$0.34 - 0.67$	Suitable
$0.68 - 1$	Very Suitable

2) analysis of student and lecturer responses. This response questionnaire is used by researchers to find out how the responses of lecturers and students as a guide to assess the practicality of the instruments developed by giving questionnaires to lecturers and students using the following scale.

Table 2: Student Response Score

Score	Answer Options
5	Strongly Agree
4	Agree
3	Disagree
2	Disagree
1	Strongly Disagree

The questionnaire results can be analyzed using the following formula (Sugiyono, 2016).

$$P = \frac{f}{N} \times 100\%$$

Description: P = Percentage; f = Number of scores from data collection; N = Number of criterion scores

Then, from the results of the analysis obtained, the next step is to conclude the results of the calculation based on the following aspects (Khairiyah, 2019)

Table 3. Attractiveness Criteria

Assessment	Criteria
$85\% \leq x < 100\%$	Very positive
$70\% \leq x < 85\%$	Positive
$50\% \leq x < 70\%$	Less positive
$x < 50\%$	Not positive

3) Analysis of student activity observation sheets. This observation sheet is used by researchers to find out how the Islamic character activities of students during the activities of working on the LKM. Analysis of the results of observations of student Islamic character activities includes giving scores to statement items that match the activities carried out by students. The next step is to calculate the percentage of student activity description with the following formula (D. D. Lestari et al., 2017).

$$Percentage = \frac{Points\ earned}{Maximum\ points}\ x\ 100\%$$

Data can be analyzed by calculating the percentage of points obtained by students and determining the criteria for student activity through the following table.

Table 4. Student Activity Criteria

Assessment	Criteria
$85\% \leq x < 100\%$	Very good
$70\% \leq x < 85\%$	Good
$50\% \leq x < 70\%$	Fairly Good
$x < 50\%$	Not Good

When the percentage of student activity is in the good and very good categories, it means that student activity can be maintained. However, when the average percentage of student activity is in the other category, then students must change their activities by paying attention to the aspects that have not been fulfilled. Furthermore, observations of students' Islamic character activities are carried out again, then analyzed again. And so on, until the average percentage of student activity is at least in the good category. 4) Data analysis of instrument test results. The test of the test instrument consists of several parts, namely:

Reliability

The reliability of this instrument uses the Chronbach-alpha formula, an assessment with the following reliability criteria (Cahyanti, Farida, & Rakhmawati, 2019).

Table 5. Reliability Criteria

Assessment	Criteria
$0{,}90 < r \leq 1{,}00$	Very High
$0{,}70 < r \leq 0{,}90$	High
$0{,}40 < r \leq 0{,}70$	Medium
$0{,}20 < r \leq 0{,}40$	Low
$0{,}00 < r \leq 0{,}20$	Very Low

Furthermore, the assessment results were calculated using the Cronbach Alpha formula as follows (Lestari, Purwanto, & Sakti, 2019).

$$r = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum si^2}{st^2}\right)$$

Description: r : reliability; si^2: variance of item I; st^2 : variance of the test; n: number of item.

Test the Level of Difficulty

The instrument difficulty index number can be obtained with the following formula (Salmina & Adyansyah, 2017).

$$TK = \frac{Mean}{Maximum\ Score}$$

Meanwhile, the criteria for the difficulty index are as follows (Purwanti, 2014).

Table 6. Criteria for the Index of Difficulty

Assessment	Criteria
$0{,}71 - 1{,}00$	Easy
$0{,}31 - 0{,}70$	Medium
$0{,}00 - 030$	Difficult

Distinguishing Power Test

The distinguishing power of the items is calculated using the following formula (Salmina & Adyansyah, 2017).

$$DB = \frac{Xt - Xr}{Xmaks}$$

Description: DB = Distinguishing power; Xt = High group average score; Xr = Average score of low groups; Xmax = Maximum Score

Meanwhile, the criteria for item power are as follows (Cahyanti, Farida, & Rakhmawati, 2019).

Table 7. Criteria for Distinguishing Power

Assessment	Criteria
$0{,}50 < x \leq 1{,}00$	Excellent
$0{,}30 < x \leq 0{,}49$	Good
$0{,}20 < x \leq 0{,}29$	Fair
$0{,}00 < x \leq 0{,}10$	Not Good
$x \leq 0{,}00$	Not Good

Student Test Data Analysis

Analysis of student test data is carried out to determine students' higher order thinking skills by correcting answers based on predetermined scoring indicators. Then, determine the score obtained with the following formula (Sugiyono, 2016).

$$P = \frac{f}{N} \times 100\%$$

Description: P = Percentage; f = Number of scores obtained; N = Maximum number of scores.

Furthermore, it can be determined the category of student ability with the category table as follows (Makmur, 2020).

Table 8. Categories of Student Ability

Score	Category
$90 < score \leq 100$	Very High
$75 < score \leq 90$	High
$60 < score \leq 75$	Medium
$40 < score \leq 60$	Low
$0 < score \leq 40$	Very Low

RESULTS AND DISCUSSION

Development Process

The process of developing test instruments for elementary linear algebra courses based on HOTS with Islamic characters is to use a formative research (Tessmer) development model.

Preliminary Stage

This stage begins with the collection of references related to this research, which is about the development of test instruments for elementary linear algebra courses based on HOTS charged with Islamic characters. Furthermore, activities are carried out to determine the place and subject of the trial. The place of trial in this study was the Faculty of Tarbiyah and Teacher Training UIN Alauddin Makassar. Meanwhile, the test subjects in this study were students of mathematics education class B, totaling 33 people.

Self Evaluation Stage

This stage consists of two parts, namely the analysis stage and the design stage. The analysis stage consists of curriculum analysis, student analysis, and material analysis.

Curriculum Analysis

Curriculum analysis is carried out to find out the basic problems in the form of how the learning plan as a reference in the process of developing HOTS-based test instruments is charged with Islamic character. The learning model that will be used in the elementary linear algebra class of mathematics education B semester 2 is an e-flipped classroom with the support of the Lantern platform and Google Meet.

Student Analysis

The student's analysis was focused on PMAT B UIN Alauddin Makassar class students who were used as trial subjects. The number of students in the PMAT B class is 33 people who have different abilities. Some are high-ability, and some are low-ability.

Material Analysis

At this stage, the researcher identifies, compiles, and details the materials that students will study that will be used in the test. Based on the results of the material analysis, it was obtained that the questions to be developed were questions that were in accordance with the material based on the learning indicators in the elementary linear algebra textbooks used in the classroom. Such materials include SPL and matrices, determinants, vectors in two-dimensional spaces and three-dimensional spaces, Euclidean vector spaces, general vector spaces, deep multiplication spaces, eigenvalues and eigen vectors, and linear transformations.
After the researcher goes through the analysis stage, the next stage is the design stage. At this stage, researchers design and design test instruments consisting of grids, story questions in the form of descriptions, answer keys, and scoring guidelines. After creating a grid that contains the subject matter, learning indicators, question indicators, measured aspects, cognitive level, question numbers, and question shapes, then the researcher designs the questions based on the grids that have been made. Researchers designed a story in the form of a description that is HOTS-based and charged with Islamic characters. The initial design of the product that has been developed can be seen in appendix A1.

Table 9. Validator Suggestions and Revisions

Validators	Instruments	Revision suggestions
Validator 1	HOTS-based test questions with Islamic characters	a. Strive for each question to be clearly depicted islamic character in it. b. Some questions should be adjusted to the verses or hadith used c. Each material indicator should be adjusted to what Islamic character you want to apply d. Consider the length of the questions made with the set time e. Make sure that the Islamic character to be achieved is ever integrated in the learning process
Validator 2	HOTS-based test questions with Islamic characters	Strive for each question to be clearly depicted islamic character in it.
	Scoring Guidelines	The use of vocabulary is improved.

Prototyping Stage

This stage begins with the collection of references related to this research, which is about the development of test instruments for elementary linear algebra courses based on HOTS charged with Islamic characters. Furthermore, activities are carried out to determine the place and subject of the trial. The place of trial in this study was the Faculty of Tarbiyah and Teacher Training UIN Alauddin Makassar. Meanwhile, the test subjects in this study were students of mathematics education class B, totaling 33 people.

Expert Review

Instrument validation is carried out by providing a validation sheet of the research instrument in the form of a test grid, test questions, and test answer keys to validators. Validators consist of two people, namely lecturers of Islamic religious education UIN Alauddin Makassar (expert 1) and lecturers of mathematics education UIN Alauddin Makassar (expert 2). Here are some revision suggestions from validators presented in table 1.

One to one

As the test instrument was validated by experts, the question was also tested on 3 6th semester mathematics education students who had gone through the elementary linear algebra course. The three students consist of students with high, medium, and low abilities based on data obtained from student study result cards. After the test instrument was tested on the three students, the student then filled out a questionnaire and wrote a comment about the HOTS-based test instrument with Islamic character.

Small Group

The revised results of expert reviews and student comments one to one are called prototype II. Then, prototype II was tested on 6 mathematics education students in semester 4. The trial was carried out for eight days, namely the trial of SPL and matrix matter questions on the first day, determinant matter on the second day, dimensional vector space matter on the third day, euclides vector space matter on the fourth day, general vector space material on the fifth day, inner result space matter on the sixth day, value matter and eigen vector on the seventh day, and the linear transformation material on the eighth day. Furthermore, the six students filled out a questionnaire to provide a review of the HOTS-based test instrument with Islamic character charged.

Field Test Stage

This stage begins with the collection of references related to this study, namely. At this stage, the prototype III design was tested in the 2nd semester B mathematics education class which totaled 33 people. Trials for SPL and matrix material questions were carried out on March 15, 22, and 29, 2021. Then, trials for determinant material questions were carried out on April 5 and 12, 2021, dimensional vector space material questions on April 19, 2021, euclides vector space materials on May 3, 2021, general vector space materials on May 17 and 24, 2021, and internal space matter on June 7 and 14, 2021, the question of value matter and eigen vector on June 21, 2021, and the problem of linear transformation material on June 28, 2021.

On the last day of the trial, researchers distributed a questionnaire in the form of a google form to find out the attractiveness and practicality of the products that have been developed.

Development Results

The validation analysis method uses the CVR (Content Validity Ratio) and CVI (Content Validity Index) methods. The results of the validation analysis can be seen in appendix A2.

Based on the table in appendix A2, it was obtained that from the 74 question items studied by two experts have shown that these items support the validity of the test content. Then from the CVR results obtained a CVI value of 1 meaning that hots-based test instruments with Islamic characters are very suitable (valid) with the material or topic being measured.

Student Response Questionnaire Analysis

The results of the analysis of student responses in the one-to-one trial obtained an average score of 72.86%. The score is included in the interpretation criterion of 70% ≤x<85% with the category “Positive”. Meanwhile, in the small group trial, an average score of 85.69% was obtained. The score is included in the interpretation criterion of 85% ≤x<100% with the category of “Very Positive” attractiveness. It can be concluded that the readability of the questions is good and can be continued to the field trial stage. From the three stages of testing that have been carried out, the results of student responses to the HOTS-based elementary linear algebra test instrument with Islamic character can be seen in chart 1 below.

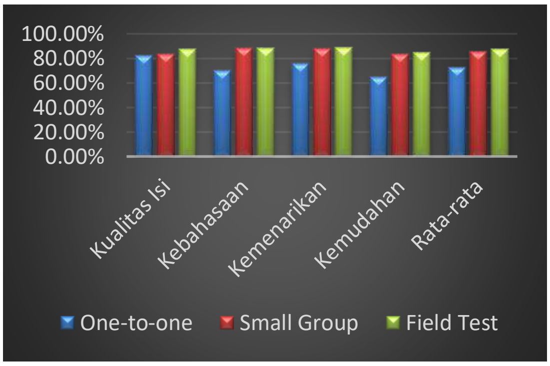

Chart 1. Analysis of Student Response

Based on the student response analysis graph above, the average assessment indicators (content quality, language, attractiveness, and convenience) show a response value above 70%. This means that the student response to the elementary linear algebra course test instrument is "Positive", so that the developed product meets the criteria of practicality.

Analysis of The Response Questionnaire of Potent Lecturers

The results of the lecturer response analysis obtained an average score obtained by the percentage of lecturer responses of 92%. This percentage falls under the interpretation criteria of 85% ≤x<100% with the category of "Very Positive" attractiveness. This indicates that the test instrument meets the practical criteria.

Analysis of Observation Sheets on Islamic Character Activities of Students

The results of the analysis of the observation sheet on the activities of Islamic characters of students can be seen in appendix 3.

Based on the table in appendix 3, the average percentage of student Islamic character activity was obtained at 80.64%. The percentage falls under the criteria of 70% ≤x<85% with the category "Good". This shows that hots-based test instruments charged with Islamic character meet the effective criteria of the affective aspect of students.

Test The Reliability of Test Instruments

Based on the results of the reliability analysis of HOTS-based test instruments charged with Islamic characters using SPSS Statistics 22, it was obtained that the test instruments were classified as reliable with an average value of Cronchach's alpha 0.968 with a very high interpretation.

Test Instrument Difficulty Level

The following are the results of the analysis of the difficulty level of the HOTS-based test instruments with Islamic characters presented in table 1 Based on Following results analysis level difficulty instrument test-based HOTS charged character Islamic.

Table 10. Test Instrument Difficulty Level Analysis

Subject Matter	Average Difficulty Rate	Category
SPL and Matrix	0.72	Easy
Determinants	0.7	Keep
Dimensioned Vector Space	0.69	Keep
Euclides Vector Space	0.7	Keep
Common Vector Spaces	0.7	Keep
Inner Times Room	0.7	Keep
Eigenvalues and Vectors	0.67	Keep
Linear Transformations	0.69	Keep
Late Average	0.69	Keep

Based on Table 10, it was obtained that the average difficulty level of the test instruments of the HOTS-based elementary linear algebra course charged with Islamic characters was 0.69. This means that the test instrument is at a criterion of 0.31-0.70 with a moderate category, meaning that the overall difficulty level is good.

Differentiating Power of Test Instruments

The following are the results of the analysis of the differentiating power of hots-based test instruments charged with Islamic characters presented in Table 11.

Table 11. Test Instrument Differentiating Power Analysis

Subject Matter	Average Power Difference	Category
SPL and Matrix	0.41	Good
Determinants	0.44	Good
Dimensioned Vector Space	0.45	Good
Euclides Vector Space	0.47	Good
Common Vector Spaces	0.43	Good
Inner Times Room	0.5	Good
Eigenvalues and Vectors	0.47	Good
Linear Transformations	0.47	Good
Late Average	0.46	Good

Based on Table 11, it was obtained that the average differentiation power of the test instruments of the HOTS-based elementary linear algebra course charged with Islamic characters was 0.46. This means that the test instrument is at a criterion of 0.30-0.49 with a good category.

Data Analysis of Student Test Results

Student test result data is seen based on the scores obtained when doing the questions with the aim of knowing the student's high-level thinking ability. If the average student's score is below 60, then it is declared low-ability and if the average student's score is above 75, it is declared high-rated. Meanwhile, if the average student's score is at 61 to 75, it is declared to be of moderate ability. The results of the analysis of the HOTS-based test instrument with Islamic character can be seen in the following chart.

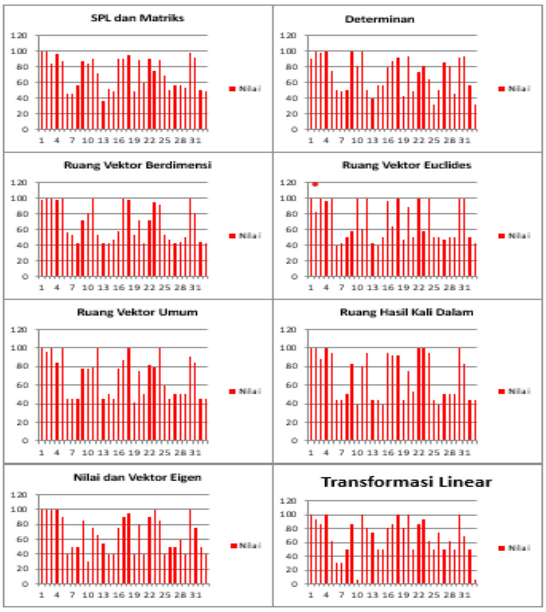

Chart 2. Test Result Analysis

Based on the graph above, the average score obtained by students is in the good category. Meanwhile, based on table A4, the average percentage of the number of students who obtained scores above 60 was 54.55% and those who obtained scores below or equal to 60 were 45.45%. Then, the average student score is 69.49%. This means that the high-level thinking ability of PMAT B class students is in the quite capable category.

Discussion

Development of test instruments for HOST-based elementary linear algebra courses with Islamic characters using a formative research (Tesmerr) development model that has a series of stages including the preliminary stage, self-evaluation stage, formative evaluation stage (prototyping) which includes expert reviews, one-to-one, and small groups, as well as the field test stage (field trials). Before the development process is carried out, researchers have set the quality criteria of the test instrument as a guideline in determining the extent of success of the developed product.

The initial stage of the formative research model is the preliminary stage, where researchers look for references to HOTS-based test instruments charged with Islamic characters. The next stage is self-evaluation, where researchers carry out curriculum analysis, student analysis, material analysis, design, and develop test instruments for elementary linear algebra courses based on HOTS loaded with Islamic characters in the form of grids, question designs, answer keys, scoring guidelines, and other research instruments.

The results of the development of test instruments are consulted with the supervisor to produce prototype I. Next, the prototyping stage which includes assessments from expert reviews, one-to-one, and small groups. The results of prototype I are given to validators as expert reviews to be assessed. Along with that, prototype I was also tested on three 6th semester mathematics education students. The assessment results from validators and student comments in the one-to-one stage are used to revise prototype I which produces prototype II. Then, prototype II was tested on six mathematics education students in semester 4. The results of the small group stage are used to revise prototype II and produce prototype III which is then tested at the field test stage. The test instruments developed before and after the revision can be seen in appendix A5.

The last stage is the field test stage, where HOTS-based test instruments charged with Islamic character are tested about the study, namely PMAT B students in semester 2. During the trial, researchers gave observation sheets to two observers as observers who supervised student activities during the process of working on the questions. After that, researchers distributed student response questionnaires and lecturer response questionnaires to be filled in which will then be analyzed to find out how the practicality of HOTS-based test instruments is loaded with Islamic characters.

Based on the results of the analysis of student responses, the average percentage of student response questionnaires was 87.40% and the lecturer response questionnaire was 92% with a very positive category, so that the test instrument was said to meet the criteria of practicality. A product is said to be practical if it gets a good response (Milala, Endryansyah, Joko, Agung, 2022). Therefore, it can be concluded that the HOTS-based elementary linear algebra course test instrument with Islamic character content that has been developed has the following characteristics.

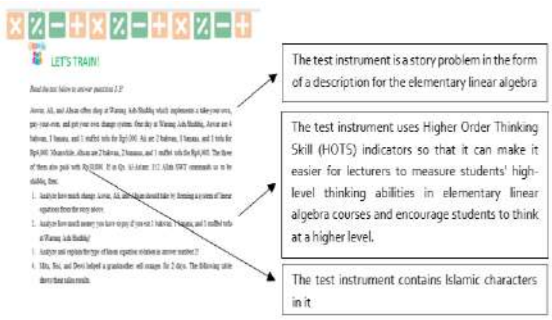

Figure 2. Problem characteristics

Furthermore, the effectiveness criteria of the test instrument are seen based on student test results and student Islamic character activity observation sheets. Based on the test results of PMAT B semester 2 students, the final average test score is 69.49 which is included in the medium ability category, so that the test instrument can meet the effective criteria in the cognitive domain of students. Meanwhile, based on the results of the analysis of the student Islamic character activity observation sheet, the average percentage of student Islamic activity is 80.64% with a good category, so that it can meet the effective criteria in the affective domain of students. Based on the results of the evaluation that has been carried out, it is found that the questions that contain Islamic characters that have been developed have a positive effect because they are in accordance with the vision and mission of the Mathematics Education Study Program which aims to produce Bachelor of Mathematics Education with Islamic civilization. Learning mathematics integrated with Islam can lead students to have knowledge and behavior in accordance with Islamic values (Imamuddin, Musril, Isnaniah, 2022; Naim, Aziz, Teguh, 2022; Supa'at & Azmi,2019).

The quality of the test instruments for elementary linear algebra courses based on HOTS charged with Islamic characters can be seen based on predetermined criteria. The validation results of the test content obtained a CVR value for each question item, namely 1 and the CVI value, which was 1. this means that hots-based test instruments charged with Islamic characters are valid. Furthermore, the response of students in the one-to-one trial obtained an average score of 72.86%. The score is included in the interpretation criterion of $70\% \le x < 85\%$ with the category "Positive". Meanwhile, in the small group trial, an average score of

85.69% was obtained. The score is included in the interpretation criterion of 85% ≤x<100% with the category of "Very Positive" attractiveness. It can be concluded that the readability of the questions is good and can be continued to the field test stage. Lecturer response analysis obtained an average score obtained by the percentage of lecturer responses of 92%. This percentage falls under the interpretation criteria of 85% ≤x<100% with the category of "Very Positive" attractiveness. This shows that the test instrument meets the practical criteria.

The analysis of the observation sheet of student Islamic character activities obtained an average percentage of student Islamic character activities of 80.64%. The percentage falls under the criteria of 70% ≤x<85% with the category "Good". This shows that hots-based test instruments charged with Islamic character meet the effective criteria of the affective aspect of students.

The results of the reliability analysis of HOTS-based test instruments charged with Islamic characters using SPSS Statistics 22 obtained that the test instruments were classified as reliable with an average value of Croncbach's alpha 0.968 with a very high interpretation. the results of the analysis of the difficulty level of the HOTS-based test instruments charged with Islamic character there are questions that have low and medium difficulty levels.

The average result of the difficulty level of the test instrument was 0.69 with a moderate category. the results of the analysis of the different power of each question item from the test instrument developed, referred to the average result of the differentiation power of 0.46 with a good category, so that the test instruments for elementary linear algebra courses based on HOTS charged with Islamic character have good quality of different power.

Based on the test results at the field test stage, in addition to obtaining the quality of the test instruments developed, the results of students' high-level thinking abilities were also obtained. The test instruments for the HOTS-based elementary linear algebra course charged with Islamic characters that have been developed have the following characteristics: (1) the test instrument is a story question in the form of a description for the elementary linear algebra course, (2) the test instrument uses the basic Higher Order Thinking Skill (HOTS) so that it can make it easier for lecturers to measure students' high-level thinking ability in elementary linear algebra courses and encourage students to high-level thinking, and (3) the test instrument contains islamic characters in it. Based on the results of data analysis, it was obtained that the average percentage of the number of learners who obtained a score above 60 was 54.55% and those who obtained a score below or equal to 60 was 45.45%. Then, the average student score is 69.49%. This means that the high-level thinking skills of PMAT B class students are in the category of moderate ability, so further efforts are needed by the lecturer to provide questions that can spur the student's high-level thinking ability.

Based on the foregoing, the developed test instrument meets valid and reliable criteria. Then when viewed from the level of difficulty, some of the question items have an easy difficulty level and others are moderate. When viewed from the level of difficulty, the question item has a good difference. Therefore, the development of a HOTS-based elementary linear algebra course test instrument charged with Islamic characters reached the final prototype.

Limitation

The questions developed have several limitations, including 1) the questions developed are limited to one course, namely elementary linear algebra. 2) The Islamic characters developed in this question are only honest, independent, tolerant, curiosity and responsibility. 3) the number of students used in this study was only 33 or one class only. 4) the cognitive abilities measured are only higher order thinking skills (HOTS).

Implication

The implication of this research on the development of HOTS-based question instruments and Islamic characters is that it can be used as an example in the preparation of HOTS questions for mathematics subjects or mathematics courses, especially for schools or universities that will integrate Islamic teachings with other subjects in general. Then the results of this study can be used as practice questions for lecturers to train and improve students' higher-level thinking skills and improve Islamic attitudes and behavior.

CONCLUSSION

The test results obtained from the HOTS-based test instruments charged with Islamic character, as seen from the results of the validation analysis of the question content, obtained an average CVI value of 1 meeting the valid criteria. The results of the reliability test of HOTS-based test instruments charged with Islamic character obtained an average of Croncbach's alpha 0.968 meeting the reliabel criteria. Meanwhile, the difficulty level of the questions obtained an average score of 0.69. The score indicates that the HOTS-based test instruments charged with Islamic character meet the medium criteria. The test results of the different power test of the test instrument obtained an average score of 0.46 which showed that the differentiation of the test instrument was of good quality. The practicality of the test instrument is seen from the analysis of student and lecturer responses of potent students and lecturers respectively by 87.40% and 92%, this means that students and lecturers give a very positive response to the test instruments of elementary linear algebra courses based on HOTS charged with Islamic characters. The effectiveness of the test instrument is seen based on the analysis of student test results and observation sheets of student Islamic character activities. Based on the results of the analysis of test results, the final average test score was obtained of 69.49 which is included in the category of capable keep. Meanwhile, based on the results of the analysis of observation sheets on Islamic character activities, students are expected to have an average percentage of Student Islamic activities of 80.64% with good categories, so that the test instrument can meet the effective criteria.

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Appendix A.

KEGIATAN 1.1.: SISTEM PERSAMAAN LINEAR, MATRIKS, DAN OPERASI MATRIKS

Nama :
Nim :
Kelas :

Alokasi Waktu : 1 × 40 menit

Petunjuk :

1. Berdoalah terlebih dahulu sebelum memulai mengerjakan.
2. Isilah identitas Anda pada tempat yang telah disediakan.
3. Baca teks soal dengan cermat lalu selesaikan secara individu.
4. Selesaikan soal dengan menggunakan 5 langkah yakni mengamati, menanya, mengumpulkan informasi, menalar, dan mengkomunikasikan.

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ

وَاَنْفِقُوْا فِيْ سَبِيْلِ اللّٰهِ وَلَا تُلْقُوْا بِاَيْدِيْكُمْ اِلَى التَّهْلُكَةِ ۛ وَاَحْسِنُوْا ۛ اِنَّ اللّٰهَ يُحِبُّ الْمُحْسِنِيْنَ

Terjemahnya : "Dan infakkanlah (hartamu) di jalan Allah, dan janganlah kamu jatuhkan (diri sendiri) ke dalam kebinasaan dengan tangan sendiri, dan berbuatbaiklah. Sungguh, Allah menyukai orang-orang yang berbuat baik." (QS. Al-Baqarah: 195).

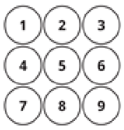
MARI BERLATIH !

1. Aswar, Ali, dan Ahsan adalah pemuda yang dermawan. Ketika berbelanja, mereka sengaja membayar lebih untuk bersedekah. Suatu hari di warung Bu Ani, Aswar memakan 4 bakwan, 1 pisang, dan 1 tahu isi. Ali memakan 2 bakwan, 1 pisang, dan 1 tahu isi. Sedangkan, Ahsan memakan 2 bakwan, 2 pisang, dan 1 tahu isi. Mereka bertiga membayar dengan uang Rp.10.000 dan menolak kembaliannya.
   a. Jika Aswar, Ali, dan Ahsan bersedekah kepada Bu Ani masing-masing sebesar Rp.5000, Rp.6000, dan Rp.4000, bentuklah persamaan linear dari peristiwa tersebut!
   b. Analisis berapa harga 1 bakwan, 1 pisang, dan 1 tahu isi berdasarkan persamaan linear pada jawaban nomor 1a!
   c. Analisis dan jelaskan jenis penyelesaian persamaan linear pada jawaban nomor 1b!
2. Mita, Sisi, dan Dewi berjualan jeruk selama 2 hari untuk membantu seorang nenek yang sedang kesusahan. Berikut tabel hasil penjualan mereka.

Nama	Hasil Penjualan	
	Hari Pertama	Hari Kedua
Mita	Rp.25.000	Rp.30.000
Sisi	Rp.30.000	Rp.25.000
Dewi	Rp.20.000	Rp.35.000

   Di hari berikutnya, nenek bersedekah di masjid sebesar Rp.20.000 dari hasil penjualan Mita, Rp. 15.000 dari hasil penjualan Sisi, dan Rp. 25.000 dari hasil penjualan Dewi. Analisis berapa uang yang dimiliki nenek di hari ketiga menggunakan operasi matriks.

3. Di suatu rumah zakat, terdapat 9 calon muzakki (orang yang memberi zakat) sedang mengantri dengan tertib.



   Tiga orang diantaranya adalah seorang perempuan, yakni nomor antrian 4, 7, dan 8. Kemudian, setelah melalui verifikasi berkas, ternyata hanya nomor antrian 2, 3, dan 6 yang memenuhi syarat menjadi muzakki (beragama Islam, bukan hamba sahaya, baligh, dan berakal).
   a. Kelompokkan calon muzakki berdasarkan cerita di atas dengan membentuk matriks diagonal, matriks segitiga atas, dan matriks segitiga bawah!
   b. Analisis jenis matriks apa yang terbentuk jika menjumlahkan matriks segitiga atas dan matriks segitiga bawah pada jawaban nomor 1a.
   c. Kalikan matriks diagonal pada jawaban nomor 1a dengan matriks yang terbentuk pada jawaban nomor 1b.
   d. Analisis dan simpulkan apa yang terjadi jika matriks pada jawaban nomor 1c ditranspose sebanyak 2 kali!

JAWABAN

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Appendix A2

Table A2. Results of CVR and CVI Validation After Revision

Item Question	Expert 1	Expert 2	CVR	CVI	Information
SPL and Matrix					
1	Yes	Yes	1		Item support
2	Yes	Yes	1		Item support
3	Yes	Yes	1		Item support
4	Yes	Yes	1		Item support
5	Yes	Yes	1		Item support

6	Yes	Yes	1		Item support
7	Yes	Yes	1		Item support
8	Yes	Yes	1		Item support
9	Yes	Yes	1		Item support
10	Yes	Yes	1		Item support
11	Yes	Yes	1	1	Item support
12	Yes	Yes	1		Item support
13	Yes	Yes	1		Item support
14	Yes	Yes	1		Item support
15	Yes	Yes	1		Item support
16	Yes	Yes	1		Item support
17	Yes	Yes	1		Item support
Determinant					
1	Yes	Yes	1		Item support
2	Yes	Yes	1		Item support
3	Yes	Yes	1		Item support
4	Yes	Yes	1		Item support
5	Yes	Yes	1		Item support
6	Yes	Yes	1	1	Item support
7	Yes	Yes	1		Item support
8	Yes	Yes	1		Item support
9	Yes	Yes	1		Item support
10	Yes	Yes	1		Item support
11	Yes	Yes	1		Item support
12	Yes	Yes	1		Item support
Vector Space Dimensions					
1	Yes	Yes	1		Item support
2	Yes	Yes	1		Item support
3	Yes	Yes	1		Item support
4	Yes	Yes	1		Item support
5	Yes	Yes	1	1	Item support
6	Yes	Yes	1		Item support
7	Yes	Yes	1		Item support
8	Yes	Yes	1		Item support
9	Yes	Yes	1		Item support
Vector Space Euclides					
1	Yes	Yes	1		Item support
2	Yes	Yes	1		Item support
3	Yes	Yes	1		Item support
4	Yes	Yes	1	1	Item support
5	Yes	Yes	1		Item support
6	Yes	Yes	1		Item support
7	Yes	Yes	1		Item support
Vector Space General					
1	Yes	Yes	1		Item support
2	Yes	Yes	1		Item support
3	Yes	Yes	1		Item support
4	Yes	Yes	1		Item support
5	Yes	Yes	1	1	Item support
6	Yes	Yes	1		Item support
7	Yes	Yes	1		Item support
8	Yes	Yes	1		Item support
9	Yes	Yes	1		Item support
10	Yes	Yes	1		Item support
11	Yes	Yes	1		Item support
Inner Product Space					
1	Yes	Yes	1		Item support

2	Yes	Yes	1		Item support
3	Yes	Yes	1		Item support
4	Yes	Yes	1		Item support
5	Yes	Yes	1		Item support
6	Yes	Yes	1	1	Item support
7	Yes	Yes	1		Item support
8	Yes	Yes	1		Item support
9	Yes	Yes	1		Item support
		Eigenvalues and Eigenvectors			
1	Yes	Yes	1		Item support
2	Yes	Yes	1		Item support
3	Yes	Yes	1	1	Item support
4	Yes	Yes	1		Item support
5	Yes	Yes	1		Item support
		Linear Transform			
1	Yes	Yes	1		Item support
2	Yes	Yes	1	1	Item support
3	Yes	Yes	1		Item support
4	Yes	Yes	1		Item support

Appendix A3

Table A3. Analysis of the Observation Sheet Activity Character Islamic Student

Activity Student	**Meeting to -**													**Average Rating**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
Active discuss with friend group	79.1	79.1	80	80.3	80.3	80.3	83	84	84.2	84.2	84.5	84.8	84.8	82.17%
Work Duty with independent and honest without cheat	71.6	71.9	76.1	77.3	74	74.6	77	77	74.3	75.5	76.4	76.4	76.4	75.25%
Submit question related questions that haven't been understood	74.6	76.1	71.2	75.2	77.9	76.7	78.8	80	83.9	83.9	84.8	84.8	85.5	79.49%
Gather Duty appropriate time	76.7	77	78.2	75.2	80.3	79.7	79.7	80	83.9	83.9	83.6	84.2	84.2	80.48%
act polite polite	71.8	72.8	77.6	80.6	79.4	87.9	90.6	89	89.1	89.7	96.7	95.2	95.5	85.84%
Final Average														80.64 %

Table A4. Analysis of Test Results Student

Theory	**Amount Mhs**	**Amount Mhs> 60**	**Percentage**	**Amount Mhs< 60**	**Percentage**	**Average value**
SPL and Matrix	33	19	57.58	14	42.42	72.01
Determinant	33	19	57.58	14	42.42	70.33
Vector Space Dimensions	33	16	48.48	17	51.52	68.6

Vector Space Euclides	33	16	48.48	17	51.52	69.81
Vector Space General	33	18	54.55	15	45.45	69.76
Inner Product Space	33	17	51.52	16	48.48	69.61
Values and Eigenvectors	33	18	54.55	15	45.45	67.27
Linear Transform	33	21	63.64	12	36.36	68.56
Final Average	33	18	54.55	15	45.45	69.49

Appendix A5

Before Revision (Prototype I)	After Revision (Protorype II)
Aswar, Ali, dan Ahsan adalah pemuda yang dermawan. Ketika berbelanja, mereka sengaja membayar lebih untuk bersedekah. Suatu hari di warung Bu Ani, Aswar memakan 4 bakwan, 1 pisang, dan 1 tahu isi. Ali memakan 2 bakwan, 1 pisang, dan 1 tahu isi. Sedangkan, Ahsan memakan 2 bakwan, 2 pisang, dan 1 tahu isi. Mereka bertiga membayar dengan uang Rp.10.000 dan menolak kembaliannya. 1. Jika Aswar, Ali, dan Ahsan bersedekah kepada Bu Ani masing-masing sebesar Rp.5000, Rp.6000, dan Rp.4000, bentuklah persamaan linear dari peristiwa tersebut! 2. Analisis berapa harga 1 bakwan, 1 pisang, dan 1 tahu isi berdasarkan persamaan linear pada jawaban nomor 1! 3. Analisis dan jelaskan jenis penyelesaian persamaan linear pada jawaban nomor 2!	Aswar, Ali, dan Ahsan sering berbelanja di Warung Ash-Shiddiq yang menerapkan sistem ambil sendiri, bayar sendiri, dan ambil uang kembalian sendiri. Suatu hari di Warung Ash-Shiddiq, Aswar memakan 4 bakwan, 1 pisang, dan 1 tahu isi seharga Rp5.000,00. Ali memakan 2 bakwan, 1 pisang, dan 1 tahu isi seharga Rp4.000,00. Sedangkan, Ahsan memakan 2 bakwan, 2 pisang, dan 1 tahu isi seharga Rp6.000,00. Mereka bertiga pun membayar dengan uang Rp10.000,00. Jika dalam Qs. Al-An'am: 152 Allah SWT memerintahkan kita untuk bersikap shiddiq, maka: 1. Analisis berapa uang kembalian yang seharusnya diambil oleh Aswar, Ali, dan Ahsan dengan membentuk sistem persamaan linear dari cerita di atas. 2. Analisis pula berapa uang yang harus Anda bayar jika memakan 1 bakwan, 1 pisang, dan 1 tahu isi di Warung Ash-Shiddiq! 3. Analisis dan jelaskan jenis penyelesaian persamaan linear pada jawaban nomor 2!.
7. Pak Dandi adalah seorang pedagang ikan yang tidak pernah mengeluh jika dagangannya tidak terjual, karena Ia percaya bahwa Allah Swt. telah mengatur rezeki masing-masing hamba-Nya. Pagi ini, Pak Dandi menjual 4 jenis ikan yang disusun rapi di atas meja berbentuk persegi. Ada 6 ikan bolu dan 3 ikan lele di baris pertama, serta 12 ikan cakalang dan 18 ikan mujair di baris kedua. Buktikan bahwa $(A^T)^{-1} = (A^{-1})^T$ apabila A adalah matriks yang dibentuk dari susunan ikan jualan Pak Dandi!	7. Suatu hari, Pak Dandi menjual 4 jenis ikan yang disusun rapi di atas meja berbentuk persegi. Ada 6 ikan bolu dan 3 ikan lele di baris pertama, serta 12 ikan cakalang dan 18 ikan mujair di baris kedua. Keesokan harinya, Pak Dandi meminta tolong kepada Ali untuk membantunya menyusun ikan dengan menukar posisi baris dan kolom dari posisi ikan jualan kemarin. Deskripsikan dalam bentuk matriks posisi ikan yang seharusnya disusun oleh Ali, jika Rasulullah SAW menganjurkan kita untuk bertanggung jawab ketika diberi amanah, kemudian buktikan bahwa invers dari posisi ikan yang Ali susun sama dengan transpose dari invers posisi ikan yang disusun Pak Dandi!
15..........Bentuklah sistem persamaan linear dari cerita di atas lalu analisis berapa jumlah ayat yang dihafal oleh Kaisan, As'ad, dan Aulia setiap 1 jam menggunakan eliminasi Gauss-Jordan!	15.....Jika anak yang menghafal 30 juz Al-Qur'an (6236 ayat) dapat memberi syafat kepada 10 anggota keluarganya kelak di akhirat, bentuklah sistem persamaan linear dari cerita di atas lalu analisis berapa jam yang dibutuhkan oleh Kaisan, As'ad, dan Aulia agar dapat memberi syafaat kepada 10 keluarganya (Gunakan Eliminasi Gauss-Jordan)!

Before Revision (Prototype I)	After Revision (Protorype II)
Aisyah ingin mempererat silaturrahmi dengan keluarganya. Ia berencana mengunjungi rumah nenek, rumah paman, dan rumah bibinya secara bergantian. Rumah nenek berada di blok 1. Rumah paman berada di blok 2. Sedangkan, rumah bibi berada di blok 3. 1. Bentuklah permutasi pola urutan kunjungan yang dapat Aisyah gunakan menggunakan blok rumah keluarganya! 2. Klasifikasikan inversi dan permutasi genap-ganjil dari jawaban nomor 1.	Aisyah ingin mempererat silaturrahmi dengan keluarganya. Ia berencana mengunjungi rumah nenek, paman, dan sepupunya. Rumah nenek berada di blok 1. Sedangkan rumah paman berada di blok 2 dan rumah sepupunya berada di blok 3. 1.Bentuklah permutasi pola-pola urutan kunjungan yang dapat Aisyah gunakan, kemudian permutasi manakah yang sebaiknya Aisyah gunakan jika Rasulullah menganjurkan untuk memuliakan orang yang lebih tua! 2.Klasifikasikan inversi dan permutasi genap-ganjil dari jawaban nomor 1.
5.Kaisan, As'ad, dan Aulia selalu memuroja'ah hafalan mereka. Berikut tabel daftar muroja'ah mereka.....	Mentor hafidz Qur'an di SD IT Al-Fityan mengarahkan Kaisan, As'ad, dan Aulia untuk melaporkan daftar surah yang telah mereka muroja'ah. Berikut daftar surah muroja'ah yang mereka tuliskan sebelum dilaporkan kepada mentor....
1.Pada Hari Raya Idul Fitri, Ayah, Bunda, Chairul, dan Dinda berangkat menuju lokasi sholat Ied menggunakan mobil. Bunda dan Dinda duduk di kursi belakang, sedangkan Ayah dan Chairul di depan. Jika ikhwan dimisalkan dengan angka 1 dan akhwat dimisalkan dengan angka 2, bentuklah matriks A – matriks persegi yang terbentuk dari posisi duduk Ayah, Bunda, Chairul, dan Dinda, dan matriks x – matriks 2×1 yang entri-entrinya merupakan entri kolom pertama matriks A, kemudian tunjukkan nilai eigen dan vektor eigennya!	Pada Hari Raya Idul Fitri, Nur dan adiknya berangkat menuju lokasi sholat Ied menggunakan mobil. Adik Nur duduk di sebelah Nur yang mengemudikan mobil. Selama di perjalanan, ia melihat dua orang tetangganya berangkat dengan berjalan kaki. Jika dalam Qs. Al-Maidah: 2 Allah SWT memerintahkan kita untuk saling tolong-menolong, kemudian Nur dan adiknya dimisalkan dengan angka 1 dan kedua tetangga Nur dimisalkan dengan angka 2, maka deskripsikan sikap yang seharusnya ditunjukkan Nur kepada kedua tetangganya dengan membentuk matriks A – matriks persegi yang terbentuk dari kondisi mobil Nur dan matriks x – matriks 2×1 yang entri-entrinya merupakan entri kolom pertama matriks A, kemudian tunjukkan nilai eigen dan vektor eigennya!
Empat orang siswa SMP IT Ar-Rahman duduk di pelataran masjid membentuk matriks persegi. Tiba-tiba, seorang guru matematika menghampiri dan memberikan mereka kaos. Siswa yang duduk di baris pertama memperoleh kaos bertuliskan angka 6 dan teman di sebelah kanannya memperoleh kaos bertuliskan angka 4. Sedangkan, Siswa yang duduk di baris kedua sebelah kanan memperoleh kaos bertuliskan angka 0 dan teman di sebelah kirinya memperoleh kaos bertuliskan angka -2. Jika A merupakan matriks yang terbentuk dari angka pada kaos keempat siswa tersebut,............	Pak Nasrun berjanji akan memberikan hadiah kepada empat orang siswa yang memiliki nilai tertinggi dalam ujian matematika. Empat orang siswa tersebut diarahkan untuk duduk di pelataran masjid membentuk matriks persegi. Pak Nasrun pun mengamanahkan ketua kelas untuk memberikan kaos bertuliskan angka 6 pada siswa yang duduk di baris pertama dan kaos bertuliskan angka 4 untuk teman di sebelah kanannya. Lalu, kaos bertuliskan angka 0 akan diberikan kepada siswa yang duduk di baris kedua sebelah kanan dan kaos bertuliskan angka -2 untuk teman di sebelah kirinya. Jika Rasulullah SAW menganjurkan kita untuk bertanggung jawab ketika diberikan amanah, maka....

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Development of Probability Learning Media PjBL-STEM Based Using E-comic to Improve Students' Literacy Numeracy Skills

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Abstract

This research is motivated by the fact that there are still many students who find it difficult to learn the probability material, which affects the students' low literacy numeracy ability. One of the efforts to improve students' literacy and numeracy skills is to innovate interactive learning media and the right approach. Therefore, this study develops interactive learning media in the form of e-comic based on Science Technology Engineering Mathematics (STEM). This research is a type of development research with the ADDIE model which has 5 stages including Analysis, Design, Development, Implementation, and Evaluation. This article will discuss Analysis, Design, and Development due to time constraints. The subjects in this study were two material experts and two media experts. This study used a data collection instrument in the form of a questionnaire. Validation of data from experts will be analyzed using qualitative descriptive analysis and quantitative descriptive analysis. The results of the validation data were calculated using the mean formula. Validation of literacy numeracy ability to get a score of 3.5 with very good qualifications and material validation to get a value of 3.8 with very good qualifications. So that the PjBL-STEM-based interactive e-comic learning media can be declared valid, practical, and effective to improve students' literacy numeracy skills and have very good qualifications. The development of interactive learning media can then be implemented in the classroom to determine the effect of media on students' literacy skills and as a reference for educators to develop interactive learning media with other PjBL-STEM to improve students' literacy skills

Keywords: Learning Media; E-comic, PjBL-STEM; Literacy Numeracy

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Abstrak

Penelitian ini dilatarbelakangi oleh masih banyaknya siswa yang merasa kesulitan dalam mempelajari materi probabilitas, hal ini berdampak pada rendahnya kemampuan literasi numerasi siswa. Salah satu upaya untuk meningkatkan kemampuan literasi numerasi siswa adalah dengan melakukan inovasi media pembelajaran interaktif dan pendekatan yang tepat. Oleh karena itu, penelitian ini mengembangkan media pembelajaran interaktif berupa e-comic berbasis Science Technology Engineering Mathematics (STEM). Penelitian ini merupakan jenis penelitian pengembangan dengan model ADDIE yang memiliki 5 tahapan yaitu Analisis, Perancangan, Pengembangan, Implementasi, dan Evaluasi. Artikel ini akan membahas Analisis, Desain, dan Pengembangan karena keterbatasan waktu. Subjek dalam penelitian ini adalah dua orang ahli materi dan dua orang ahli media. Penelitian ini menggunakan instrumen pengumpulan data berupa angket. Validasi data dari ahli akan dianalisis menggunakan analisis deskriptif kualitatif dan analisis deskriptif kuantitatif. Hasil validasi data dihitung dengan menggunakan rumus mean. Validasi kemampuan literasi berhitung mendapatkan nilai 3.5 dengan kualifikasi sangat baik dan validasi materi mendapatkan nilai 3.8 dengan kualifikasi sangat baik. Sehingga media pembelajaran e-comic interaktif berbasis PjBL-STEM dapat dinyatakan valid, praktis, dan efektif untuk meningkatkan kemampuan literasi berhitung siswa dan memiliki kualifikasi sangat baik. Pengembangan media pembelajaran interaktif selanjutnya dapat diimplementasikan di dalam kelas untuk mengetahui pengaruh media terhadap kemampuan literasi numerasi siswa dan sebagai acuan bagi pendidik untuk mengembangkan media pembelajaran interaktif dengan PjBL-STEM lainnya untuk meningkatkan kemampuan literasi numerasi siswa.

INTRODUCTION

Indonesia is a country whose people are still known to have a low level of cultural literacy. It was followed with increasing sophistication tends to result in community technology being reluctant to read and apply a literacy culture. According to Widiantari et al. (2022) the literacy skills of students in Indonesia, especially in the field of literacy numeracy is still low. This is indicated by the results of the PISA and TIMSS tests shown respectively that Indonesia got a math score of 387 out of the average score of 490, while in TIMSS Indonesia got a math score of 395 out of the average score of 500. In line with the importance of literacy culture, numeracy also plays a crucial role in some aspects of life in everyday society. Teaching numeracy or mathematical literacy already should be given to children since he is still at a level of Elementary School gradually.

Mathematics is one of the most important learning materials in the world of education but it is also one of the lessons that are considered difficult by students (Siregar, 2017). Moreover, students have difficulty learning mathematics on probability materials (Anggara, et al., 2018). Probability in mathematics is centered on two kinds of probabilities: empirical and theoretical.

This can be seen from the achievement of math scores on probability material which is still low, there are still some students who score below 75 there are 16 out of 22 students still find it difficult to work on probability material, this is because students do not take advantage of the time given by the teacher (Putridayani & Chotimah, 2018). In addition, the research by Garfield et al., (2008) shows the basic concept of probability is still very difficult for students because it is deeply learned and often contradicts many of their own beliefs about data and probability. In addition, it is still difficult for students to understand when learning probability because teaching materials are inadequate, such as only using power points and videos viewed from YouTube, so students get bored faster because they are taught with inadequate methods and teaching materials. Therefore, students need an innovative learning approach, teaching materials, and media that can increase their literacy and numeracy skills and help them in the learning process.

Based on several research results,

one learning model that is very relevant to help with problems is Project Based Learning (PjBL). PjBL is a model that uses the project as the core when the learning process is carried out (Meita et al., 2018). In this lesson, students are invited to make projects that focus on product development and solving problems (Anggraini & Ariyanto, 2017). In addition, the effort that can be done is to provide treatment to help students, the treatment in question is to apply STEM integrated Project Based Learning (PjBL-STEM) learning.

STEM education is an important tool for improving understanding and knowledge in a particular field (Siregar et al., 2019). According to Nursyahidah & Mulyaningrum (2022) to acquire and practice 21st-century skills we need an approach through STEM-based education that involves students. The integration of STEM activities can lead to thinking skills that can help students to form the ability to evaluate, analyze, and make arguments and conclusions correctly and logically about the problems to be solved (Ling Chia et al., 2018). STEM integration can make students active, creative, critical, and communicative (Alias et al., 2014). In STEM activities, students will study problems contextually and focus on applying STEM knowledge to solve everyday problems (Berland et al., 2014).

One of the important elements in the learning process is the learning media (Prakasiwi et al., 2021). The rapid development of technology has resulted in more varied learning media (Adnan et al., 2017). One of the learning media that can be used to help them easier to convey learning objectives is comics (Mery et al., 2022). The use of e-comic is very effective as a learning medium which is seen from the psychomotor, cognitive, and affective aspects (Hermawan et al., 2018). E-comic can be made and developed into a very interesting medium to realize the effectiveness of students in the implementation of the learning process of science material.

Mathematics e-comic is used by students for learning resources independently or in class, which consists of educational elements that are tailored to the material, environment, and needs of students (Nalurita et al., 2019). E-comic is one of the teaching materials that can be used on online media on the internet, intranet, or other computer network media (Buchori & Setyawati, 2015). The use of attractively packaged comics can be used to shape students' characters by entering character values in comics (Taufiq et al., 2020).

Learning media-based adobe animation is a media that can be used in the probability learning process. Adobe Animate can be implemented in learning activities. Adobe Animate was previously known as Adobe Flash Professional, Macromedia Flash, and FutureSplash Animator (Lardinois, 2020). Adobe Animate is very suitable to be used to create interactive learning media because researchers can create animations easily and freely (Pujiyantini et al., 2021).

Based on the influence of the e-comic learning media on the student learning process as well as the PjBL-STEM learning model above, the purpose of this study is to develop a PjBL-STEM-based e-comic learning media on probability material to improve students' literacy numeracy skills. According to research conducted by (McCaslin, 2015), constructivism and cognitive principles in the integrated learning process in STEM project-based learning.

METHOD

In this study, the type of research used is development. The model used in this study is the ADDIE model which consists of five stages, namely analysis, design, development, implementation, and evaluation. The researcher uses this type of research and the research model aims to produce and test the effectiveness of the e-comic that is designed systematically. The stage chart of the ADDIE model used in this study is presented in the Figure 1.

Figure 1. The ADDIE Instructional Design Model

At the needs analysis stage, the analysis stage is to identify the material from the syllabus that is following the curriculum. The analysis phase used has 3 ways, namely curriculum analysis, characteristic analysis, and media analysis. Curriculum analysis by identifying Core Competencies, Basic Competencies, and Achievement Indicators at each meeting. Characteristic analysis by analyzing the character of Junior High School one Limpung which is the target of the e-comic research. In addition, there is media analysis analyzing this media such as e-comic when given to students, it can help when teaching and learning and is very feasible to use. Furthermore, at the design stage, the researchers designed the e-comic, including designing the storyline, shaping the characters, designing conversations between characters, making sketches, and coloring the e-comic. At the development stage, the previously designed e-comic was then consulted with the supervisory lecturer. There are four experts, namely two media experts and two material experts. After the experts have validated, then the e-comic that has been designed is carried out a deficiency analysis which will then be a guide in revising the e-comic to make it better.

This study used a data collection instrument in the form of a questionnaire. The validation data from these experts will be analyzed using qualitative descriptive analysis and quantitative descriptive analysis. The results of the validation data were calculated using the mean formula. The validation of literacy numeracy skills got a score of 4.57 with very good qualifications and material validation got a score of 4.65 with very good qualifications. After validating with the experts, the next step is to determine this validation to see the agreement of the experts in assessing the validity of the developed e-comic. The qualitative descriptive analysis method was obtained from criticism and suggestions from experts and supervisors. While the quantitative descriptive analysis method was obtained by calculating the scores of the experts on the validation sheet which was then searched for the average using the calculation of the expert scores on the validation sheet which was then searched for the average using a four-scale rating guideline. So that the PjBL-STEM-based e-comic learning media can be declared valid, practical, and effective to improve students' literacy numeracy skills and have very good qualifications. The development of interactive learning media can then be implemented in the classroom to determine the effect of media on students' literacy numeracy skills and as a reference for educators to develop interactive learning media with other PjBL-STEM to improve students' literacy numeracy skills.

The subjects who will assess the e-comic validation test are four experts consisting of two media experts and two material experts. The object of this research is e-comic validation regarding probability. This research was conducted using a questionnaire where the types of data are qualitative data and quantitative data. This research data collection uses a rating scale, with guidelines for collecting individual data in the form of numbers which are interpreted in descriptive form. This study uses a research scale sheet in the form of a questionnaire sheet with a scale of 1-4 (1 = not good, 2 = not good, 3 = good, 4 = very good). The stages in validity research are making instrument grids, consulting grids with supervisors, compiling instruments, and conducting validity with media and material experts. The validity sheet of the e-comic instrument that was developed covers seven aspects, namely the writing display, the image display, the comic media function aspect, the feature aspect, the content aspect, the construction aspect, and the linguistic aspect.

The validation instrument sheet has media experts and e-comic material experts. For media experts, there are four aspects in the first aspect, namely the appearance of writing which has indicators such as writing titles on e-comic media, the font size in e-comic media, use of dialogue words, clarity of writing on e-comic media, and ease of understanding the storyline. through the use of language. Furthermore, the image display has several indicators such as the shape of the image, the variation of the image, the suitability of the image with the text, and the color composition. In addition, there is a function of comics media that has indicators such as comics media as learning resources, delivery materials used by comics learning media can be understood by students, comics learning media can attract reading interest, comic learning media encourage students to carry out learning activities so that learning objectives are achieved. Then for the last one, the characteristic of having also has several indicators such as the presentation of comic illustrations leading to understanding the concept, the proportion of comics as entertainment and knowledge enhancers, and comic media adding to the pleasure when reading them and encouraging readers to read them completely. If the e-comic material expert validation instrument has three aspects, the first aspect, namely the content aspect, the content aspect has several indicators that are validated such as the suitability of the material content with the syllabus, the suitability of the material with core competencies and basic competencies, the suitability of the material with teaching needs, suitability learning materials with indicators that will be achieved by students, the benefits of the material for adding insight into students' knowledge, ease of understanding learning materials, and the truth of the substance in learning materials. The second aspect of the construction has indicators to validate, namely the meaningfulness of the learning material, the suitability of the learning material with the level of student ability, clarity in learning objectives, motivating students, order of presentation in learning materials, systematics of learning materials, and completeness of information in the learning process. material presentation. The last aspect is the language aspect, the language aspect has several indicators such as clarity in providing information, legibility, effective and efficient use of language, use of interesting dialogues or texts that lead to understanding concepts, and use of communicative language.

The third stage is the development stage. At this stage, e-comic media will be developed following the designs that have been made and input from a mentor. The e-comic learning media that have been developed consists of three parts, namely the opening, the content, and the closing. The next stage is the fourth stage, namely the implementation stage. At this implementation stage, what is done is the application of -based e-comic PjBL-STEM in 9th-grade students of State Junior High School 1 Limpung. The fifth stage is the evaluation stage. This evaluation stage is the last stage of Addie. At this stage, it is done to look at the results of student learning by looking at the results of pre-test and post-test during trials conducted on students of the Limpung State Middle School.

RESULTS AND DISCUSSION

Results

In this development, a product is made in the form of PjBL-STEM-based e-comic learning materials to be used as probability materials for Class VIII SMP in the even semester. This research is the development of PjBL-STEM-based e-comic learning media which is implemented with the ADDIE model. According to Sugiyono (2015), the ADDIE model has 5 stages, namely: (1) analysis stage, (2) design stage, (3) development stage, (4) implementation stage, and (5) evaluation stage. However, the implementation and evaluation stages were not carried out in the study due to time constraints.

Analysis

At this stage, it is carried out in 3 stages, namely analysis of student characteristics, analysis of student characteristics curriculum, and media analysis. The analysis of the characteristics of students finds that junior high school students are at the age of 12-15 years where at this age students enter the stage of concrete-formal cognitive development, and students begin to think abstractly and logically. For this reason, students need learning media that can help to develop students thinking skills. An analysis curriculum is done by analyzing core competencies, and basic competencies, and determining indicators of competency achievement in the material.

On analysis media, the e-comic media created must meet the criteria of several of the following aspects: (1) The visual aspect, in this aspect the e-comic must meet the appropriateness of the image from the storyline, the suitability of the background, the layout of the preparation images, and the suitability of coloring; (2) Typographical aspects, in this aspect of e-comic, must meet the selection of text types appropriate, text readability, and text size; (3) The aspect of characterization, in this aspect of e-comic, must meet conformity characters; (4) The material aspect, in this aspect the e-comic must meet the suitability of the material specified learning, clarity in conveying messages, and ease of understanding; (5) Linguistic aspect, this aspect e-comic must meet language suitability which is used with the correct language rules, the use of sentences that are easy to understand and effective, and efficient, and the use of punctuation and clear symbol.

Design

At this stage, it is done by designing PjBL-STEM-based e-comic learning media, determining the characters, designing storylines, making conversation scripts, and coloring characters. In making the design of the e-comic learning media, it was designed with the help of Adobe Animate software. The e-comic design is presented in Figure 2 and Figure 3.

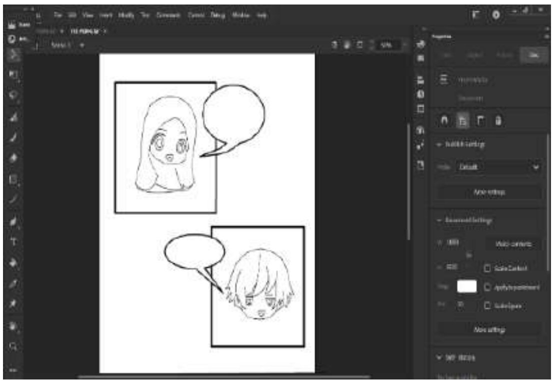

Figure 2. The design of the e-comic

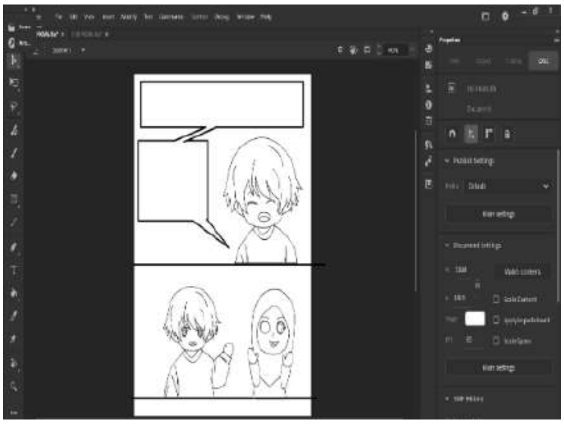

Figure 3. The design of the e-comic

In this study, in addition to STEM-based e-comic, there are several instruments including test instruments (pre-test and post-test questions). The pre-test was used to determine the student's initial abilities before using STEM-based e-comic. While the post-test was used to determine the students' abilities after using STEM-based e-comic.

Development

At this stage, the e-comic media will be developed according to the designs that have been made and input from the accompanying lecturers. The e-comic learning media that has been developed consists of three parts, namely the opening part, the content part, and the closing part. The opening section consists of a cover and a character introduction. The content section consists of a character dialogue about a project that will be made and an overview of the material. The closing section consists of instructions for working on student activity sheets and conclusions. The STEM-based e-comic media is divided into six series, the first series is about making STEM-based projects, the second series is about e-comic statistical material, the first is related to analyzing data and determining the median mean and mode, the third series contains the next material is the distribution of data consisting of ranges and quartiles, the fourth series contains e-comic material probability, which are related to empirical probability and theoretical probability, the fifth series contains e-comic material probability, which are related to the relationship between empirical probability and theoretical probability. The following is presented in figure 4, figure 5, figure 6, and figure 7 which are the e-comic opening, content, and closing sections.

Figure 4. The opening part of the PjBL-STEM-based e-comic learning media

Figure 5. The opening part of the PjBL-STEM-based e-comic learning media

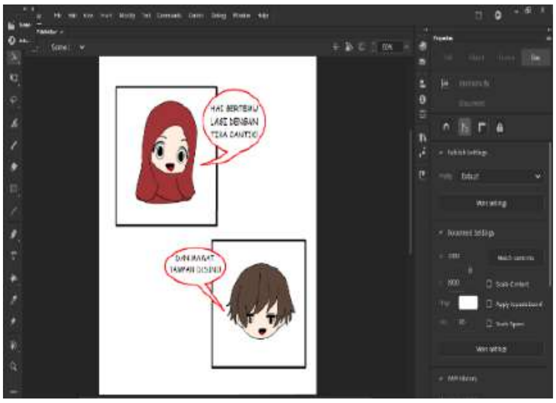

Figure 6. Contents of STEM-based e-comic learning media

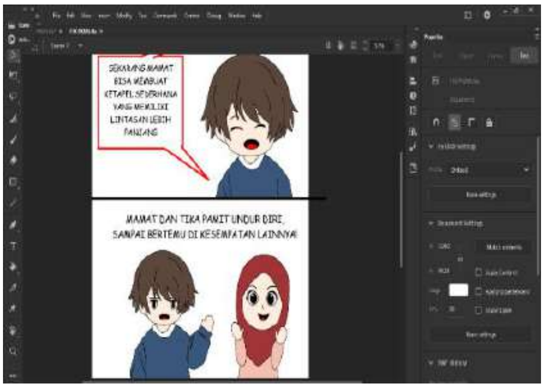

Figure 7. The closing part of the STEM-based e-comic learning media

Then after developing a STEM-based e-comic, the next step is to do a validation test by experts. The validation test was carried out by material experts and media experts for STEM-based e-comic. The names of validators and their roles are shown in Table 1.

Table 1. List of validators

Validator	Description
Dina Prasetyowati, S.Pd., M.Pd.	Material expert validation Media expert validation
Dr. Muhammad Prayito, S.Pd., M.Pd.	Material expert validation Media expert validation

The validation of the PjBL-STEM-based e-comic learning media test validation with the topic of probablity is carried out offline by giving validation test sheets to two material experts and two media experts. Based on comments and suggestions from media experts, it shows that in the validation assessment of PjBL-STEM-based e-comic media oriented to literacy numeracy skills, the criteria are very good, with a score of 4 (very good) and 3 (good). From the results of the distribution of the score, the result is 3.5 with very good qualifications. The results of the validation test by material experts on the suitability of the curriculum and the suitability of the learning material were spread at a score of 4 (very good) and 3 (good). From the results of the distribution

The score was obtained at 3.8 with very good qualifications. Based on the results of the study, shows that the PjBL-STEM-based e-comic learning media for probability for junior high school materials developed in this study shows valid or feasible results. The following table shows the results of the average validation scores by media experts in table 2.

Table 2. Media expert validation results

Aspect	Score	
	Validator 1	Validator 2
Writing	19	15
Pictures	20	16
E-Comic Media Function	15	14
Characteristics	11	10
Total	65	55
Average	3,5	
Qualification	Very good	

Furthermore, the results of material expert validation can be seen in table 3.

Table 3. Results of material expert validation

Aspek	Score	
	Validator 1	Validator 2
Content	27	28
Construct	27	25
Language	20	29
Total	74	72
Average	3,8	

The following are the revisions from material experts and media experts along with the results after the revision.

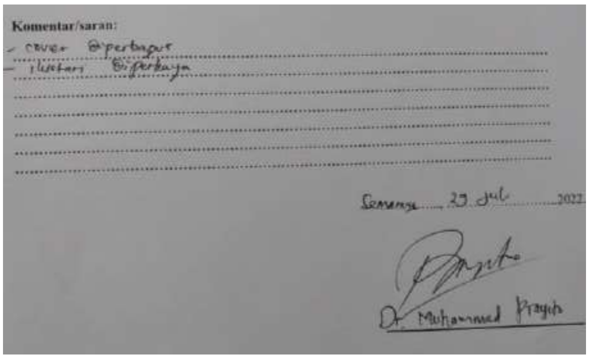

Figure 8. Comments/suggestions

Figure 9. Before revision

Figure 10. After revision

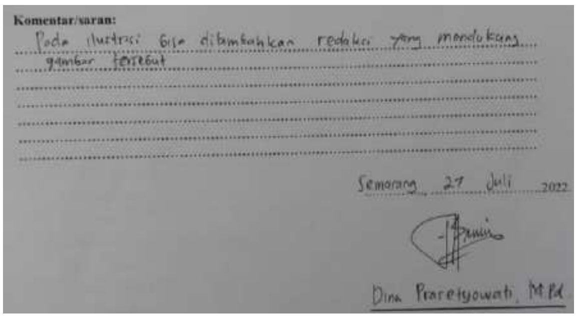

Figure 11. Comments/suggestions

Figure 12. After revision

Implementation

At this implementation stage, what is done is the application of STEM-based e-comic to 9th-grade students of State Junior High School 1 Limpung. At this stage, three classes were carried out, namely the small class, the experimental class (e-comic STEM), and the control class (conventional). In a small class, 6 students were taken to be given a pre-test, then continued with the provision of e-comic and student activity sheets, and closed with a post-test. In the Experiment class, 31 students were taken to be given a pre-test, then continued with the provision of STEM-based e-comic and student activity sheets, and closed with a post-test. The control class (conventional) was given a pre-test and then given conventional learning without using e-comic media, then closed with a post-test. The implementation of e-comic in some of these classes can be seen in Figure 13, Figure 14, and Figure 15.

Figure 13. Implementation of e-comic

Figure 14. Implementation of e-comic

Figure 15. Implementation of e-comic

Evaluation

This evaluation stage is the last stage of ADDIE. At this stage, what is done is to see the results of student learning by looking at the results of the pre-test and post-test during the trials conducted on students of the State Junior High School 1 Limpung. After learning in the experimental class (e comic PjBL-STEM) and control class (conventional) is completed, students will be given post-test questions for final data analysis. This final data analysis was conducted to determine whether there were differences in learning outcomes in the form of students' literacy numeracy skills between the experimental class (e-comic PjBL-STEM) and the control class (conventional). The following steps are carried out in the final data analysis.

Normality test

The normality test aims to determine whether the sample taken is from a population that is normally distributed or not.

Table 4. Results of the Final Data Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Pre Test Eksperimen (E-comic)	.102	31	.200*	.959	31	.271
Post Test Eksperimen (E-comic)	.087	31	.200*	.978	31	.753
Pre Test Konvensional	.120	31	.200*	.946	31	.118
Post Test Konvensional	.101	31	.200*	.965	31	.393

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance

Based on table 4, it can be seen that the significance value (Sig.) for all data, both in the Kolmogorov-Smirnov test and the Shapiro-Wilk test, shows a value > 0.05. So it can be concluded that the data for this study is normally distributed.

Test of Homogeneity of Variance

Once it is known that the research data is normally distributed, the homogeneity test will then be carried out on the research data. This homogeneity test was conducted to determine whether the experimental class and control class had homogeneous (same) or heterogeneous (unequal) variances.

Table 6. Results of Independent Sample t Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
Students learning outcomes	Equal variances assumed	.088	.768	3.789	60	.000	7.806	2.060	3.686	11.927
	Equal variances not assumed			3.789	59.481	.000	7.806	2.060	3.685	11.928

Table 5. Results of Homogeneity Test Analysis

Students learning outcomes

Levene Statistic	df1	df2	Sig.
.088	1	60	.768

Based on Table 5, it can be seen that the significance value (Sig.) Based on the Mean is 0.768 > 0.05, it can be concluded that the variance of post-test data in the experimental class and post-test data in the control class is the same or homogeneous.

Independent Test Sample t Test

The independent sample t-test aims to determine whether there is an average learning outcome in the form of literacy numeracy skills in the experimental class that is better than the control class. This test is also to find out one indicator of the effectiveness of learning media products.

Based on Table 6, the significance value (Sig.) is 0.000 < 0.05. So it can be concluded that there is a difference in the average learning outcomes in the form of students' literacy numeracy skills between the experimental class and the control class.

Table 7. Student Learning Outcomes

Class	N	Mean	Std. Deviation	Std. Error Mean
Post-test Experiment	31	83.45	8.481	1.523
Post-test control	31	75.65	7.722	1.387

Based on Table 7, it can be proven that the average class that uses e-comic PjBL-STEM is 83.45 while the average class that does not use e-comic PjBL-STEM is 75.65. From this analysis, it can be concluded that there is an increase in the average score in the experimental class compared to the control class. So that the PjBL-STEM e-comic learning media can be declared effective.

The next step was to test the practicality of the e-comic PjBL-STEM. At the end of the lesson, students were given a student response questionnaire to the PjBL-STEM e-comic learning media.

Table 8. Average student response questionnaire

		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
N	Valid	31	31	31	31	31	31	31	31	31	31
	Missing	0	0	0	0	0	0	0	0	0	0
	Mean	3.97	4.55	4.35	4.32	4.45	4.55	4.55	4.52	4.58	4.48

Based on the data in Table 8, it can be seen that the response of students to the PjBL-STEM e-comic media with an overall average result of 4.8. So it can be said that e-comic is practical. In addition, based on student responses in the learning process that has been carried out, it can be concluded that most students anthusistic the learning media because e-comic learning media can help students understand probability and can also increase students' enthusiasm for learning.

This is in line with research by Dwidevi (2014), that one of the learning models that are considered to be effectively able to integrate STEM is the Project based learning model. In addition, the research conducted by Wicaksana and Ridlo (2017) also supports the results in this study that using the PjBL (project-based learning) learning model can improve the character of students' epistemic curiosity and have an influence on mathematical literacy skills.

Discussion

Based on the results of the development, it was found that the PjBL-STEM-based e-comic learning media developed using the ADDIE model were declared valid, effective, and practical. With the validation results showing an average score by media experts showing a score of 3.5 with very good qualifications and by material experts showing a score of 3.8 with very good qualifications, it can be said that e-comic is valid. The practicality test of e-comic learning media is carried out by giving a student response questionnaire to e-comic learning media by obtaining an average score of 4.8, so it can be said that e-comic is practical. The average in the experimental class showed an increase compared to the control class so the e-comic was declared effective to improve students' literacy numeracy skills. The results of this study are in line with research conducted by Octaria, et al., that learning media is said to be good if it meets the aspects of validity, practicality, and effectiveness (Octaria et al., 2022).

The PjBL-STEM-based e-comic learning media for probability materials developed received a positive response from students. This is supported by Siregar et al., (2019) that e-comic media in learning mathematics is more effective than using the lecture method in learning. the use of e-comic media makes it easier for students to understand and allows students to master learning objectives better. Students do more learning activities because they don't just listen to the teacher's explanation, e-comics can increase student motivation and learning achievement (Budi, 2016; N. Siregar et al., 2019). Research result of Cahyani et al., (2020) stated that the STEM-integrated Project Based Learning e-module increases creativity and student learning outcomes, although not significantly, it is still in the moderate category. The PjBL learning model with the STEM approach also has advantages in the implementation of learning. The advantage of this PjBL is that it can increase student learning motivation by making students more active and successful in solving complex problems, improve problem-solving skills, enhance collaboration, encourage students to develop and practice communication skills, and can improve student skills in managing various sources (Raitu & Kurniawan, 2016). Learning using the STEM approach has the potential to create meaningful learning because students are trained to solve mathematical problems through projects that are integrated with one or another field of knowledge. Apart from that, STEM also provides students with the experience that mathematics has real benefits for everyday life (Indriani, 2020). Based on this description, this study packaged PjBL-STEM-based probability learning media using e-comic. The new thing in this research is an e-comic based PjBL-STEM learning media on probability material that is able to improve students' literacy numeracy skills and increase students' interest and motivation to learn. The new thing in this research is a e-comic based PjBL-STEM learning media on probability material that is able to increase students' interest and motivation to learn.

Implication of Research

Based on the results of this study obtained theoretical and practical implications. The theoretical implication is, by using PjBL-STEM can affect students' learning motivation, thereby affecting student achievement. The practical implication is that this research can be used as input for teachers and prospective teachers to pay attention to learning media, learning methods, and appropriate approaches.

Limitation

Based on the researcher's direct experience in this research process, some limitations can be considered for further research. Some of the limitations of these studies include: (1) The material studied only focuses on probability material for class VIII; (2) In the data collection process, the information provided by the respondents sometimes did not reflect the true opinions of the respondents. This happened because of different thoughts, assumptions, and different understandings for each respondent as well as other factors such as honesty in filling out the packet.

CONCLUSION

Based on the research and development that has been carried out, it can be concluded that the product developed is in the form of e-comic PjBL-STEM for probability material declared: (1) valid based on the media expert test with a score of 3.5 with very good qualifications and the material expert test with a score of 3.8 with very good qualifications good, (2) practical based on student response questionnaires with an average score of 4.8, (3) effective based on an increase in the average score where the class that uses e-comic PjBL-STEM is 83.45 and the class that does not use e-comic PjBL -STEM is 75.65. From the description of the results above it is known that the development of PjBL-STEM e-comic is feasible to be applied to students and suitable to be used as a companion for learning mathematics.

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Learning Obstacles of Prospective Mathematics Teachers: A Case Study on the Topic of Implicit Derivatives

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Abstract

This research is a Didactical Design Research (DDR), aiming to identify various learning barriers for prospective mathematics teachers. Some students still experience learning difficulties in derived concepts which are prerequisites for other concepts or other subjects, didactic and pedagogical anticipation can be prepared to overcome them. Based on the learning design, various learning barriers were identified, especially in the implicit derivative concept. The research participants consisted of 3 lecturers and 46 second-semester prospective teacher students at one of the tertiary institutions in Indonesia. The results of interviews and questionnaires were analyzed through identification, clarification, reduction and verification techniques and then presented narratively. The results showed that some prospective teachers experienced learning barriers 1) ontogenic instrumental, conceptual, and psychological types, 2) didactic, students could not identify contextual relationships in the structure of answers, indicating that the material was not by the continuity of students' thinking, and 3) epistemological, the lack of understanding of explicit and implicit similarities shows the limitations of the context that students have. Based on the research findings, a learning design will be developed based on the theory of a didactic situation with the stages of action situations, formulation, validation, and institutionalization, which are thought to be able to overcome the findings of learning obstacles.

Keywords: *Didactical Design Research; Implicit Derivatives; Learning Obstacle; Prospective Mathematics Teachers*

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Abstrak

Penelitian ini merupakan Didactical Design Research (DDR), bertujuan untuk mengidentifikasi berbagai hambatan belajar calon guru matematika. Sebagian mahasiswa masih mengalami hambatan belajar pada konsep turunan yang merupakan prasyarat konsep lain atau matakuliah lain, dapat disiapkan antisipasi didaktis maupun pedagogis untuk mengatasinya. Berdasarkan rancangan pembelajaran, diidentifikasi berbagai hambatan belajar khususnya pada konsep turunan implisit. Partisipan penelitian terdiri dari 3 dosen dan 46 mahasiswa calon guru semester dua di salah satu perguruan tinggi di Indonesia. Hasil wawancara dan angket dianalisis melalui teknik identifikasi, klarifikasi, reduksi, dan verifikasi, selanjutnya disajikan secara naratif. Hasil penelitian menunjukkan bahwa beberapa calon guru mengalami hambatan belajar 1) ontogenik tipe instrumental, konseptual, dan psikologis, 2) didaktis, mahasiswa tidak dapat mengidentifikasi hubungan kontekstual dalam struktur jawaban, menunjukkan bahwa materi tidak sesuai dengan kesinambungan proses berpikir mahasiswa, dan 3) epistemologis, kurangnya pemahaman persamaan eksplisit dan implisit menunjukkan keterbatasan konteks yang dimiliki mahasiswa. Berdasarkan temuan penelitian, akan dikembangkan desain pembelajaran berdasarkan theory of didactical situation dengan tahapan situasi aksi, formulasi, validasi, dan institusionalisasi yang diduga dapat mengatasi temuan hambatan belajar.

INTRODUCTION

Calculus is the study of change that uses derivation as the main tool. Many things related to solving mathematics, physics, and other branches of science cannot be solved by geometry and algebra, hence, calculus is needed (Rohde et al., 2012). Various fields apply derivatives, including economics, biology, physics, geography, and sociology. The derivation is among the mathematical concepts taught at the university to learn different concepts, other subjects, or real-world applications (Tarmizi, 2010; Tall, 2012; Pepper et al., 2012). Specifically, it is essential in differential calculus courses and a prerequisite for several courses in the Mathematics Education Study Program. Most undergraduate students find derivatives difficult due to a lack of conceptual understanding (Willcox & Bounova, 2004; Tarmizi, 2010; Tall, 2012; Pepper et al., 2012). Hashemi *et al*. (2014) concluded that students had a weak conceptual understanding, scoring 8.7 out of 20. Sahin *et al*. (2015) showed that second-year postgraduate students had fewer derivatives understanding. The explanations did not reveal the role of big ideas or modeling connections in derivatives. Unver *et al*. (2018) suggested that prospective mathematics teachers require modeling training with feedback at each stage.

Students experience difficulties with the derivative concept, including determining the derivative of rational functions and chain rules (Tokgöz, 2012) and maximum and minimum values (Fatimah & Yerizon, 2019). In general, they make fundamental errors in derivatives and those that cannot be understood conceptually (Orton, 1983). They have difficulties applying the calculus concepts in modeling and applications, especially in the real world (Roorda et al., 2007). Various factors cause difficulties in derivative concepts, such as the learning system (Habre & Abboud, 2006) and students' ability (Gray & Tall, 1991). The lecture's design that cannot help students connect implicit differentiation components causes difficulties in understanding derivatives (Borji, V., & Martinez-Planell, 2020).

Prospective mathematics teachers have difficulty constructing evidence due to inability to apply definitions and concepts (Noto et al., 2019), lack of prerequisite knowledge (Guler, 2016), negative attitude (Doruk & Kaplan, 2015), and lack of experience and knowledge (Şengül & Katranci, 2015). Gurefe (2018) stated that prospective mathematics teachers could not explain concepts using symbols. The order of the concept of derivatives in textbooks generally starts with the definition of derivatives, unilateral derivatives, derivatives of polynomial functions, derivatives of products and quotients of two functions, higher order derivatives, chain theorem, implicit derivatives, and applications of derivatives. Students' ability to determine implicit derivatives depends on their understanding of the types of underlying equations and various rules for finding explicit derivatives. In general, students can determine the derivative of an implicit function by first converting it into an explicit form. Problems arise when the implicit equation given cannot be presented in an explicit form. The presentation of the material in the learning design is not following the students' experience in learning the concept. The concepts of functions, quotients, and product derivatives are given long before the implicit derivatives. When the implicit derivatives and these concepts become the primary tools, some students experience difficulties because the questions provided do not follow their thinking experience.

This implies that high school students and mathematics or engineering majors have learning difficulties in derivatives. Aspiring math teachers experience similar difficulties as their peers from other programs. The learning experience of prospective teachers positively impacts their beliefs (Lo, 2020), helping students overcome various difficulties. This is in line in with Mufidah *et al.* (2019), which stated that there is a difference between teacher image and scientific derivatives conceptions.

Brosseau's (2005) Theory of Didactical Situation (TDS) states that external factors cause learning obstacles, specifically didactical design (Suryadi, 2019). Since there is no best learning process, the teacher's didactic design does not follow the level of thinking, profile, and students' learning style. Additionally, the material does not follow the continuity of students' thinking, or the didactic design has limited context. Jaafar and Lin (2017) stated that there is no a suitable approach/intervention for students. Their profiles should be determined at the beginning of the semester to understand their weaknesses.

Brousseau (2002) divided learning obstacles into ontogenic, didactical, and epistemological. Ontogenic obstacles are related to students' mental readiness and cognitive maturity to receive knowledge. Furthermore, Suryadi (2019) stated that ontogenic obstacles reflect the difficulty of didactic situations, inhibiting students' learning participation. Didactical obstacles are caused by sequence factors and curriculum stages, including classroom presentation. They are minimized by arranging the material structurally (connections between concepts) and functionally (continuation of the thought process). The third type of obstacles is caused by limited understanding and mastery of concepts, problems, or others associated with a narrow context based on experience.

Suryadi (2019) categorized ontogenic learning obstacles into three, psychological, instrumental, and conceptual. Duroux (in Suryadi, 2010) stated that epistemological obstacles reflect a person's knowledge limited to a specific context. Students experience learning obstacles caused by mental readiness and cognitive maturity in receiving knowledge, the order of textbook material, or lecturer's presentation. Furthermore, these obstacles are caused by limited understanding and mastery of concepts, problems, or others with specific contexts.

Harel (2009) stated that mathematics has two complementary subsets: first, a collection or structure, including axioms, definitions, theorems, proofs, problems, and solutions. Second, ways of thinking through mental action characteristics of the first subset product. Following Harel's opinion, NCTM (2014) stated that mathematics is not a collection of separate topics and abilities but a unified whole. Furthermore, it should not be viewed as a product but an activity. Students construct their mathematical knowledge through various activities, including patterns, generalizing, and abstractions to form a concept (Suryadi, 2010). Based on this, a prospective teacher should be equipped to provide students opportunities to construct knowledge from a series of expertise. Kirschner *et al.* (2006) stated that students must build mental representations or schemas regardless of complete or partial information, where complete information gives accurate and easy terms.

Previous studies did not identify the types of obstacles, hence the need to categorize problems or obstacles to anticipate and overcome multiple student obstacles, such as didactic design. Previous research focused on students, disregarding prospective mathematics teachers. Various difficulties related to derivatives revealed in previous research were found in high school students, engineering students, and mathematics students. This research will focus on student math teacher candidates, considering that they will spearhead the success of a learning process if they are already teachers. The experience of prospective mathematics teachers in overcoming various learning obstacles will be helpful for them in helping overcome student learning obstacles at the school level. Knowing the various learning obstacles experienced by prospective mathematics teacher students is an effort by a lecturer to understand from a student's point of view how they carry out their thinking processes so that they can be taken into consideration in designing a learning process, including creating learning designs along with their didactic and pedagogical anticipations.

Therefore, this specific research questions include: (1) What are the types of ontogenic learning obstacles experienced by prospective mathematics teachers on implicit derivatives? (2) What are the types of didactical learning obstacles experienced by prospective mathematics teachers on implicit derivatives? (3) What are the types of epistemological learning obstacles experienced by prospective mathematics teachers on implicit derivatives?

METHOD

This qualitative research used the Didactical Design Research (DDR) design. Indonesia developed DDR in 2010 (Suryadi, 2019), as a form of educational innovation (Sidik et al., 2021), exploring the teachers' learning designs characteristics and impact on students' thinking development (Fuadiah et al., 2019; Suryadi, 2019). DDR's philosophy provides active learning situations to construct learners' ways of thinking and understanding mathematics knowledge (Marfuah et al., 2022). The interpretive paradigm was applied to examine the impact of didactic design on student thinking (Creswell, 2014; Denzin, Norman and Lincoln, 2018; Suryadi, 2019). According to Suryadi (2011), DDR includes didactic analysis before learning through a Hypothetical Didactic Design, including the Anticipation of Pedagogical Didactics (ADP), considering the learning obstacle. This research identified various learning obstacles for prospective mathematics teachers on implicit derivatives from the aspect of learning design developed by lecturers. n simple terms, the research stages are presented in Figure 1 below.

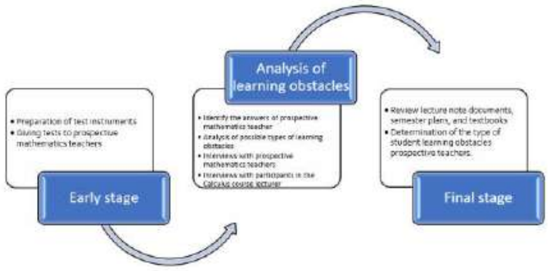


Figure 1. Research Step

Brosseau (2002) identified three learning obstacles, ontogenic, epistemological, and didactic. DDR revealed various students' thinking and obstacles, especially prospective mathematics teachers. The learning obstacles for prospective mathematics teachers were identified based on the lecturers' learning design and effect on students' implicit derivatives understanding.

Learning obstacles caused by cognitive maturity and mental readiness of students to receive knowledge are called ontogenic learning obstacles; if a didactical system causes it, for example, sequence factors, stages in the curriculum, including presentation in the learning process, then learning barriers are called didactical learning obstacles; and if it caused by limitations in students' mastery and understanding of something that is limitedly associated with a particular context adapted to the experiences they experience, then learning barriers are called epistemological learning obstacles. Ontogenic learning obstacles are divided into three types, namely (1) psychological types, learning barriers caused by cognitive maturity and psychological factors of students in acquiring knowledge; (2) instrumental types, learning barriers caused by not mastering critical technical matters of a problem being solved; (3) conceptual type, learning barriers caused by the conceptual level contained in the learning design.

The participants consisted of three female lecturers aged 40 – 57 who were interviewed and provided a semester course plan for the Differential Calculus course, needed for analysis. This study focused on the concept of implicit derivatives. The lecturers had relevant educational backgrounds, teaching Differential Calculus for 5-25 years. Furthermore, the participants included 46 second-semester students of the Mathematics Education Study Program at a university in West Java, Indonesia aged between 18-21, where 39 were female and 7 males. The students involved had taken 40 of the required total credits (145 credits), 3 of which are Differential Calculus courses.

The research was conducted during the Covid-19 pandemic; hence the online lectures were based on distance learning. Therefore, educators utilize technological advances to create a practical and satisfying learning experience (Burdina et al., 2019). The data were collected from test results, questionnaires, interviews, and document reviews.

In qualitative research, there are four criteria for data validity: credibility, transferability, dependability, and confirmability (Denzin, Norman, and Lincoln, 2018; Moleong, 2017; Sugiyono, 2016). Credibility is synonymous with external validity in quantitative research, carried out through the following steps: (a) directly involved in the research site during the data collection process; (b) thorough and detailed at the time of data collection and analysis adapted to the research objectives; (c) using technique and source triangulation; (d) peer review; (c) adequacy of references, keeping authentic evidence of the results of research data collection. With these stages, the researcher can obtain complete data and be accounted for so that the research findings have the correct accuracy from the perspective of researchers, participants, and readers. Transferability, synonymous with external validity in quantitative research, can be seen from the research setting, determination of participants, and data processing. This stage ensures that this research provides sufficient information to the reader about the cases studied to determine the degree of similarity between the cases studied and cases whose findings can be transferred to other issues. Dependability is synonymous with reliability in quantitative research, carried out by examining the entire research process, starting from problem identification, preparation of research instruments, checking data accuracy, and data analysis quality. Confirmability in quantitative research is known as objectivity, carried out by examining the objectivity and transparency of the findings and discussion of the research.

The students determine implicit derivatives depending on their understanding of types of equations, including 1) explicit, with variables x and y on different sides, 2) implicit, with the variables on the same side. In the second case, there are those presented in an explicit form and those that cannot be delivered in an explicit condition. Students have studied how to find and determine derivatives of implicit functions by converting them into explicit forms. The problems arise when the implicit equation cannot be presented in an explicit form, as discussed in this research. For this reason, a test was designed to assess various prospective mathematics teachers' obstacles detected through the stages presented in the questions. The student's understanding depends on prerequisite materials, including explicit equation derivatives, rules, basic ideas, and application. The test questions were structured to identify the continuity of students' thinking patterns, starting with their ability to relate and utilize prerequisite material and determine the derivatives of various implicit equations and applications.

The test had 3 questions, including 1) implicit equation presented in explicit form. Part a guided the students to convert it into an explicit form, while part b asked them to determine the derivative based on a. Part c asked them to determine the equation's derivative without first converting it into explicit form. They were asked to conclude the b and c results in the last section. This question determined the students' understanding of prerequisite knowledge and implicit derivatives. 2) an equation in an implicit form not explicitly stated, asking the students to determine the equation's derivative using the implicit derivative. This question determined their understanding of derivatives, solved with implicit derivatives. 3) the implicit derivative application problem determines the Tangent and Normal Line Equation. This question determined students' abilities in applying implicit derivatives to problems.

The test was given to student participants to determine various obstacles and their understanding of implicit derivatives. Furthermore, unstructured interviews were conducted on several students with specific characteristics for further exploration. Lecturers were interviewed to determine their learning designs, obstacles in presenting the material, student learning obstacles, solutions, and input for effective lectures.

The student participants filled out questionnaires to substitute class observations. The questions were arranged to describe the studied situation, providing equivalent information as direct observations. However, further information was obtained by interviewing several students for clarification. The questionnaires and interviews followed the tests on implicit derivatives. Therefore, the researcher was not involved and did not treat the participants' class activities. Subsequently, field observations involved document reviews of student test results, lecture notes, semester lecture plans, and textbooks. The data analysis techniques included identification, clarification, reduction, and verification, presented narratively.

RESULTS AND DISCUSSION

Results

The identification and analysis of various learning obstacles for prospective mathematics teachers were categorized following the research questions. The first research question showed three ontogenic obstacles, namely instrumental, conceptual, and psychological types. Meanwhile, the second research question only revealed the didactic type of learning obstacles. Finally, the third research question revealed the epistemological type of learning obstacles. Each obstacle included screenshots of students' work and interview excerpts, as described in the following sections.

What Are the Types of Ontogenic Learning Obstacles Experienced by Prospective Mathematics Teachers on Implicit Derivatives?

Prospective mathematics teachers experience technical errors that hinder problems solving. This problem was detected when students solved the implicit derivative application question to determine the Tangent and Normal Line Equation of $\frac{x^2}{9}+\frac{y^2}{36}=1$ at the point $(-1, 4\sqrt{2}\,)$. Some of the answers shown in Figure 2 (See Appendix).

These answers indicate difficulty in determining the form of $\frac{dy}{dx}$ and the tangent line equation. Students could not solve the problems due to a lack of key technical matters mastery, including the real numbers of properties, Cartesian coordinates, and gradient. The questionnaire results reinforced the learning obstacles experienced.

Researcher: What difficulties have you experienced in determining the derivative of an implicit function?
Student-1: Missed item when determining derivatives of an implicit function, using the product derivative of two functions.
Student-3: Difficulty in applying derivatives.
Student-15: Likes to be wrong when determining $\frac{dy}{dx}$.
Student-28: In the implicit derivative, I thought y as x function.

The responses of Student-1, Student-3, and Student-15 indicated a lack of key technical understanding of the problems, namely the product derivative adaptation in implicit derivatives with two variables simultaneously. The student-28 response indicated a lack of technical understanding of the general principle of implicit derivatives; hence both problems were not solved properly.

The test and questionnaire analysis showed that technical errors often cause errors in solving questions. Therefore, the prospective teachers' mistakes in determining the tangent and normal lines included ontogenic obstacles of the instrumental type.

The ontogenic obstacle with conceptual type, relates to the question's conceptual level, not the student's thinking experience. Weak understanding of rational function derivatives causes difficulties, as shown in Figure 3 (See Appendix).

Several answers identified a weak understanding of the rational function derivative $y=\frac{u}{v}$. Some students understood the derivative function as $y'=\frac{u\prime}{v\prime}$. The errors occurred because the lecture on implicit derivatives provided questions in polynomial functions, causing difficulties when solving a rational function. The problem was traced in the students' lecture notes. Apart from the derivative of the rational function, several errors were identified due to a weak understanding of the product derivative for two functions. The problem was revealed when determining the derivative of $x^2y + xy^2 = 3x$, as shown in Figure 4 (See Appendix).

Some answers showed a weak understanding of the product derivative of two functions, namely $y = u.v$. Some students lack understanding of the function's derivative as $y' = u'v + v'u$. There were different errors, specifying $u'.v$ and $v'.u$ due to a weak understanding of implicit derivatives. Students lack understanding of implicit derivatives as a concept that requires another, namely chain proposition, and considering variable y as a function of x.

The interviews showed that some students did not know the derivative of a rational function and product of two functions, while some could not apply them to implicit derivatives. Therefore, the lack of this understanding affects other topics with similar concepts. Students should understand the concept before discussing implicit derivatives. The Differential Calculus lecturer interviews confirmed students' difficulties, as shown below:

Researcher: According to your experience, what are the students' difficulties when learning implicit derivatives?
Lecturer-1: The variables x and y often confuse students in determining the correct derivation rule.
Lecturer-2: Some students forget to derive implicit functions using the derivative search and chain rule.
Lecturer-3: Students have difficulty deriving the multiplication and division of functions.

The questionnaires showed these difficulties due to a weak understanding of implicit derivatives, as shown below:

Researcher: Difficulties encountered when determining the implicit function derivative.
Student-10: The y-derived symbol to x is not written because y′ is alternated with y, despite having different meanings.
Student-25: I am confused about what to take first when using the chain theorem.
Student-28: Forgetting that I was considering y as a function of x.
Student-39: Determining implicit derivatives using the chain theorem.

Weak understanding of algebraic concepts and characteristics of function derivative rules cause obstacles, as revealed answers in Figure 4 (See Appendix).

Various difficulties were caused by the conceptual level in the lecturers' learning design, disregarding the student's learning experience. Students have obtained the derivative of rational functions, the derivative of the product of two functions, and the chain theorems before studying implicit derivatives. The designs lacked an explicit effort to link the studied concepts with the student's previous knowledge. The tests, interviews, and questionnaires analyzed the difficulties as conceptual ontogenic obstacles. Furthermore, the obstacles were due to the question's unmatched conceptual level with the student's thinking experience.

This research did not find the explicit ontogenic constraints with psychological type. The lack of mastery of prerequisite materials on the basic concepts of derivatives and various rules has hindered the study of implicit derivative. These problems are attributed to the lack of student interest in implicit derivative concepts, classified as a psychological ontogenic learning obstacle.

What Are the Types of Didactical Learning Obstacles Experienced by Prospective Mathematics Teachers on Implicit Derivatives?

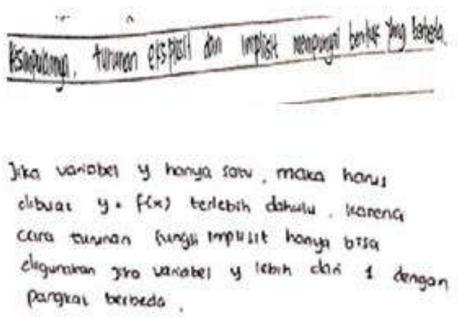
Obstacles can occur when the learning materials lack the continuity of students' thinking. Some students do not understand the questions, providing wrong answers (see below).

Given the function $xy + 2x + 3x^2 = 4$
a. changes the equation in the form $y = f(x)$;
b. based on part a determine the value *of* $\frac{dy}{dx}$;
c. without part a, can $\frac{dy}{dx}$ be determined? if yes, determine the value.
d. conclusions from sections b and c results.

Some students solved part a using implicit derivative (Figure 5 part (i)). However, when answering part c, they wrote it in the form $y = f(x)$ before determining the derivative (shown in Figure 6. Part (ii). - See Appendix). Some students determined the explicit form in part a but used implicit derivative to determine part b (Figure 6. part (iii) - See Appendix).

The obstacles were caused by order of the material, disregarding the continuity of students' thinking. This affected their knowledge reflected in their work and lecture notes. There was inadequate explanation of the relationship between implicit and explicit equations and utilizing explicit equation derivatives to determine implicit equations derivatives converted into explicit equations.

The weak understanding of implicit equations and derivatives affected part d. Some students cannot conclude whether the implicit equation derivative is the same, first converted into $y = f(x)$, or directly uses implicit derivative. Some answers were as follows.



Author's translation:

- Conclusion: Implicit and explicit derivatives have different forms
- In case there is only one variable, y, the equation needs to be changed to the form $y = f(x)$, because the implicit derivative can only be used if the variable y is more than one with different ranks.

Figure 6. Examples of errors in drawing conclusions

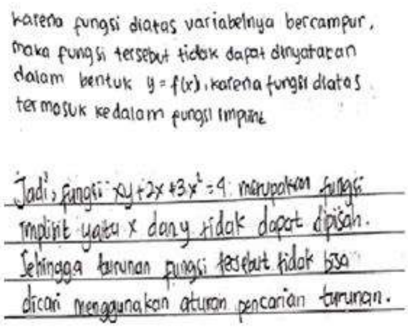
Obstacles for prospective teachers cannot conclude whether the results were similar. The continuity of students' thinking is not by the problem's context. Students did not complete the situation, determine the contextual relevance in the answer, or have limited context. They solved problems following the work examples, as reinforced by the lecturer's interviews below.

Researcher: When teaching and learning "Implicit Derivatives," what is the order of the applied materials?
Lecturer-1: Define implicit function and find its derivative.
Lecturer-2: Derivative, derivation search rule, trigonometric functions, implicit derivative, and chain rule.

The interview results showed that the order of the material lacked an explicit description of the relationship between implicit derivatives and functions. The lecture notes lacked stimulating examples for students to conclude the derivative functions determined in two ways, either convert into an explicit equation (that can be changed) or directly use implicit derivatives. This condition is shown in the order of material on the applied syllabus. Furthermore, the problem is well presented when traced in the sourcebook. The results showed that students experience didactical obstacles due to the sequence of material, exercises, and types of questions.

What Are the Types of Epistemological Learning Obstacles Experienced by Prospective Mathematics Teachers on Implicit Derivatives?

Some students experienced obstacles due to a lack of understanding of the two types of equations meaning when solving an implicit equation $xy + 2x + 3x^2 = 4$, converting it into an explicit equation $y = f(x)$ to determine the derivative function. Some of the answers included:


karena fungsi diatas variabelnya bercampur, maka fungsi tersebut tidak dapat dinyatakan dalam bentuk y = f(x), karena fungsi diatas termasuk kedalam fungsi impilit

Jadi, fungsi xy+2x+3x²=4 merupakan fungsi implisit yaitu x dan y tidak dapat dipisah. Sehingga turunan fungsi tersebut tidak bisa dicari menggunakan aturan pencarian turunan.

Author's translation:

- The function above has mixed variables, hence cannot be expressed as $y = f(x)$, and is included in the implicit function.
- The equation $xy + 2x + 3x^2 = 4$ is an implicit function because the x and y variables are inseparable, hence the derivative search rule cannot determine its derivative.

Figure 7. Examples of the epistemological type of learning obstacle

Weak understanding of the explicit and implicit equations differences causes obstacles when solving implicit function derivatives, as revealed in the student's interviews below:

Researcher: What is the difference between explicit and implicit equations?
Student-11: Explicit and implicit equations have separable and inseparable coefficients, respectively.
Student-4: The explicit equation is $y = f(x)$ with arbitrary variables.
Student-27: An explicit equation has one variable, while an implicit has two.
Student-40: Explicit equations are solved faster than implicit.
Student-44: Implicit functions cannot be represented by $y = f(x)$.

The questionnaires indicated a weak understanding of explicit and implicit equations. Some students had difficulties distinguishing equations' variables, coefficients, and constants. The student's lecture notes showed the explicit equation directly presented as $y = f(x)$; no examples showed whether the explicit equation could be obtained from the implicit. Furthermore, there was a minimal explanation of implicit equations, giving direct examples of implicit derivatives without associating explicit derivatives of functions. A student stated that they had difficulty "solving a different question from the example given." Therefore, they cannot solve problems due to limited context, causing epistemological obstacles. Some students could change the implicit equation into the form $y = f(x)$ but made an error in determining the derivative, as shown in Figure 7 (See Appendix).

The mistakes are attributed to the weak mastery of basic quotient derivatives concepts, as revealed from the student's interviews: they can easily determine the quotient derivative when the numerator and denominator contain variable x but have problems with the variable only appearing in the numerator or denominator. Some students stated that they could not use the quotient derivative when determining the derivative of $y = \frac{1}{x}$, given the derivative of 1 as 0. Furthermore, they believed that the derivative of $y = \frac{x}{3}$ could be determined using the quotient derivative rule. They did not know another way of determining the second derivative of a given function. Some realized that the two functions derivatives could be determined using the power derivative $y = x^n$ guided by the rational and linear function's derivative questions. Limited context caused a weak understanding of rational function derivatives, where the given examples contained variable x in the numerator and denominator; hence a different form caused obstacles. Therefore, the students experience epistemological obstacles in determining implicit derivatives.

Discussion

The findings revealed that prospective mathematics teachers experience various learning obstacles on implicit derivatives. This is caused by external factors such as mental readiness to receive knowledge, lecturers' didactical designs, and limited context. Various obstacles were due to the weak understanding of rational function derivative and product of two functions. The results are in line with Tokgoz (2012), which stated that students have difficulty in rational function derivatives and chain theorems. Tarmizi (2010), Tall (2011), Pepper (2012), dan Hashemi (2014) found a weak understanding of derivative concepts considered difficult by students. Orton (1983) concluded that students from the mathematics department made fundamental errors in the concept of the derivative. Furthermore, the weak mastery of prerequisite material hindered implicit derivative problem-solving. This supports other studies that students have difficulty understanding limits, requiring prerequisite mastery before the derivative concept (Kim et al., 2015; Wahyuni, 2017; Fatimah & Yerizon, 2019). Nurwahyu *et al.* (2020) concluded that students experience misconceptions using the basic formula for derivative functions.

The tests and interviews revealed that some students experienced obstacles solving implicit derivative problems due to a limited understanding of chain theorem and keywords of implicit derivatives. This is in line with Borji and Martinez-Planell (2020), which stated that chain rule and implicit function are crucial in achieving coherence of implicit derivative schemes, namely explicit functions, derivatives, and search rules. An implicit function process conception and chain rule schema should be constructed based on the function composition coherence.

The lecturers' didactical design causes a didactical learning obstacle, including the sequence of material, position of prerequisite material, and the question. Lecturers should develop a didactic design, allowing students to construct knowledge without significant obstacles. This supports Amzat *et al.* (2021) that teachers should educate and develop the curriculum. In addition to the order of the material, the didactic design needs to contain didactic and pedagogical anticipations that make it easier for students to construct knowledge. The results of this study are in line with the research of Darmawan et al. (2021). They concluded that students often feel doubtful about the answers given after the teacher provides intervention in the form of dialogical questions.

This research identified and analyzed various learning obstacles in the implicit derivative concept based on Brousseau (2002) and determined various causes. Specifically, this result can help prepare didactic and pedagogical anticipations for future learning.

Implication of Research

The various obstacles identified show the need for good planning, including alternative didactic designs to assist students overcome various learning obstacles. The recommended didactic design contains four steps allowing students to construct knowledge; First, presenting the problem through discovery, solving strategies, or rules on implicit derivatives that stimulate students' thinking. Second, understanding the problems in the first stage, with didactic and pedagogical anticipation to assist students to achieve knowledge. Third, students are faced with situations that allow improvement or strengthening of the concepts learned. Fourth, presenting various problems to measure students' ability to apply concepts in different contexts. This supports the Theory of Didactical Situations with four stages, action situation, formulation, validation, and institutionalization.

Limitation

This research focused on second-semester students of the Mathematics Education Study Program, using a small part of the courses in the curriculum structure. Furthermore, online lectures hinder individual services. The research focused on the first stage of DDR by identifying various learning obstacles on implicit derivatives from the lecturers' learning design.

CONCLUSION

The prospective mathematics teacher students experienced difficulties caused by external factors categorized as obstacles. Instrumental type of ontogenic Learning Obstacles causes difficulties in derivatives functions and tangents equations. The ontogenic learning obstacle conceptual type causes difficulties in determining the derivative of an implicit function because of a weak understanding of the derivative of a rational function and the derivative of the product of two functions. Psychological obstacles reflect minimal interest in implicit derivatives due to lack of prerequisite material mastery. In contrast, didactical learning obstacles are caused by lack of material continuity based on students' thinking processes. This is identified when students cannot conclude the derivative of an implicit function, solve the problem, and find the contextual relationship. Finally, epistemological learning obstacles were due to limited context, showing a weak understanding of explicit and implicit equations and difficulties using rational function derivatives.

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Appendix

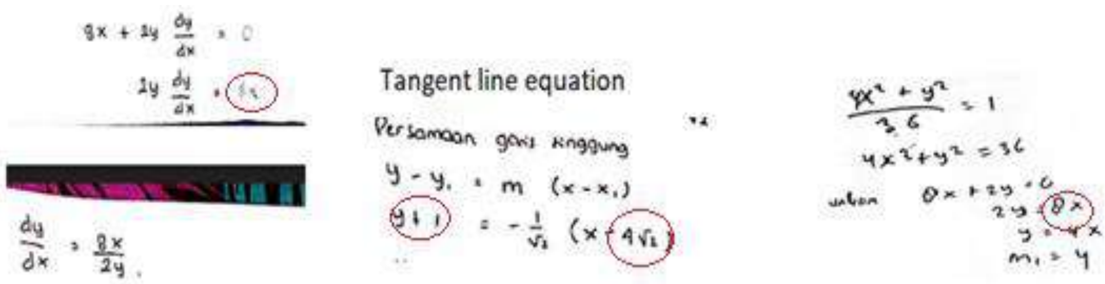

Figure 2. Examples of instrumental type ontogenic learning obstacle

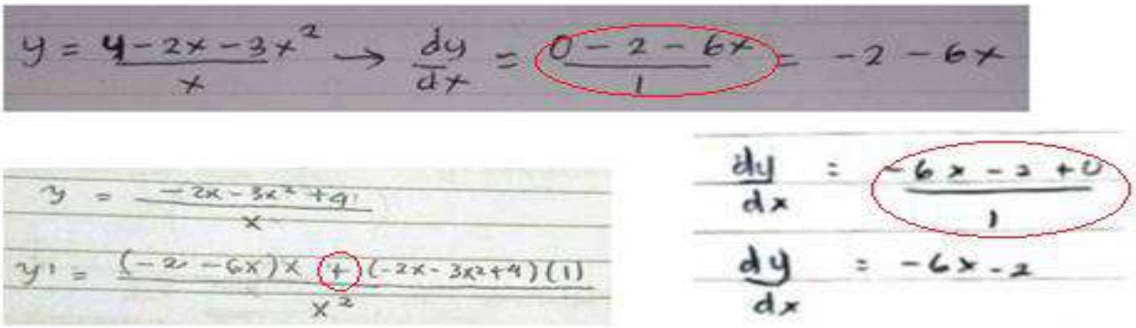

Figure 3. Examples of conceptual-type ontogenic learning obstacle on the derivative of rational functions

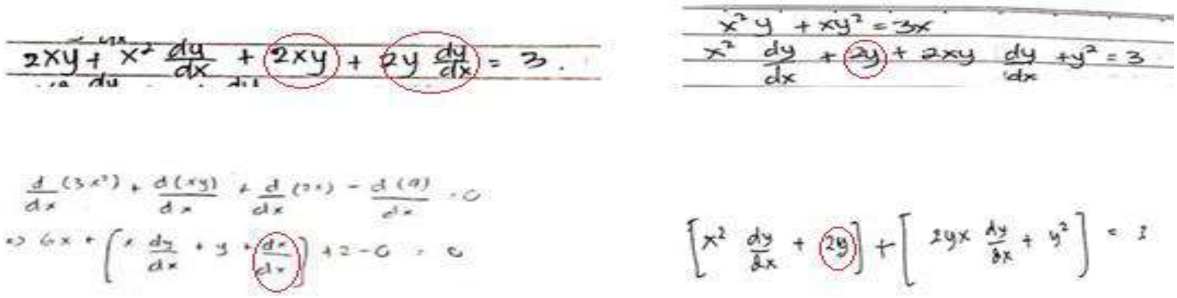

Figure 4. Example of conceptual type ontogenic learning obstacle on the product derivative of two functions

Figure 5. Examples of weak understanding of algebraic concepts

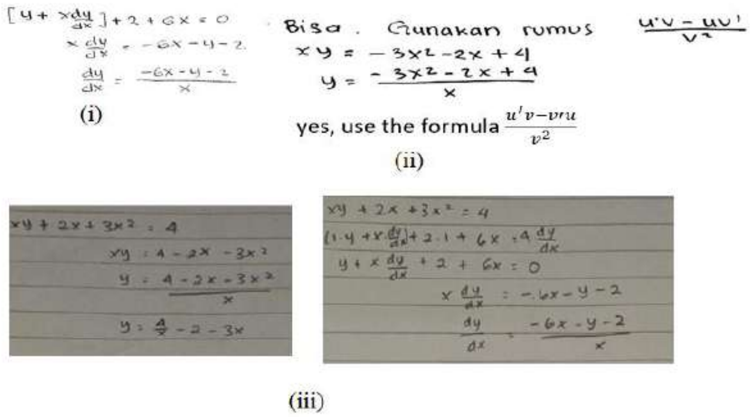

Figure 6. Examples of weak understanding of implicit equations and derivatives.

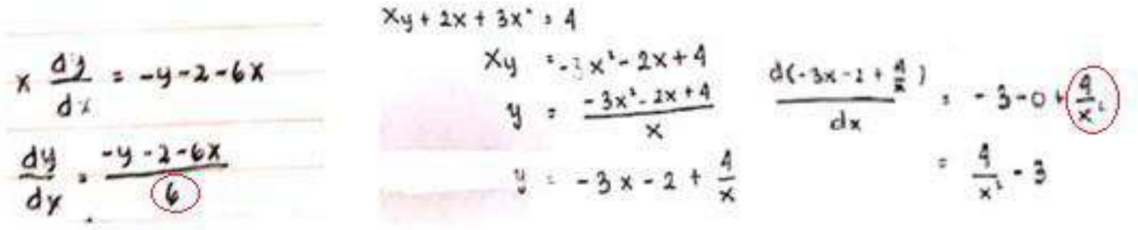

Figure 7. Examples of the epistemological type of learning obstacle

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Scaffolding to Help Numeracy Literacy Mild Mental Retardation Children on The Introduction of The Value of Money

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Abstract

The existence of ABK (Children with Special Needs) in inclusive schools still requires assistance from accompanying teachers. However, the limited number of accompanying teachers causes the learning process of ABK to be not optimal, including in improving numeracy literacy skills regarding the introduction of the value of money. Therefore, this study aims to assist in the form of scaffolding for mild mental retardation who attend inclusive schools at SMP N 1 Salatiga in the 2022-2023 academic year. Research begins with identifying initial capabilities, types, and causes of errors followed by implementation scaffolding right. This qualitative research data collection technique includes test methods, interviews, and documentation with a method and time triangulation process. The results showed that the subject experienced misunderstanding, transformation, and process skills. The same type of error, with different causes, can result in different scaffolding given. Scaffolding that succeeds in helping Mild Mental retardation in recognizing the value of money is level 1 (Environmental Provisions), level 2 by type Explaining and Restructuring as well as Scaffolding level 3 (Developing Conceptual Thinking).

Keywords: ABK; Scaffolding; The Value of Money; Numeracy Literacy.

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Abstrak

Keberadaan ABK di sekolah inklusi, tetap memerlukan pendampingan dari guru pendamping. Akan tetapi, terbatasnya jumlah guru pendamping menyebabkan tidak optimalnya proses belajar ABK termasuk dalam meningkatkan kemampuan literasi numerasi akan pengenalan nilai uang. Oleh karena itu, penelitian ini bertujuan untuk memberikan bantuan berupa scaffolding terhadap Tunagrahita Ringan yang bersekolah di sekolah inklusi SMP N 1 Salatiga pada TA 2022-2023. Penelitian dimulai dari pengidentifikasian kemampuan awal, jenis dan penyebab kesalahan yang dilanjutkan dengan pengimplementasian scaffolding yang tepat. Teknik pengumpulan data penelitian kualitatif ini mencakup metode tes, wawancara dan dokumentasi dengan proses triangulasi metode dan waktu. Hasil penelitian menunjukkan bahwa subjek mengalami kesalahan pemahaman, transformasi dan keterampilan proses. Jenis kesalahan yang sama, dengan penyebab yang berbeda, dapat mengakibatkan perbedaan scaffolding yang diberikan. Scaffolding yang berhasil membantu Tunagrahita Ringan dalam mengenal nilai uang adalah level 1 (Environmental Provisions), level 2 dengan jenis Explaining dan Restructuring serta Scaffolding level 3 (Developing Conceptual Thinking).

INTRODUCTION

In Law No. 20 of 2003 concerning the National Education System, article 5 section 1 reads: "Every citizen has the same right to obtain quality education". Furthermore, in section 2 it is stated that citizens who have physical, emotional, mental, intellectual, and/or social disabilities have the right to obtain special education. This means that the government is obliged to provide quality education to every citizen, including Children with Special Needs or often referred to as ABK.

ABK is a child who has limitations or extraordinary abilities, both physical, mental-intellectual, social, and emotional, which significantly influence the process of growth or development compared to other children of the same age (Setiawati, 2020; Winarsih et al., 2013). ABK has been divided into 12 categories and one of them is mental retardation (Ayuning et al., 2022; Kemendikbud, 2014). Mental retardation is a condition where an individual has mental retardation, below the average normal child in general. *American Association on Mental Deficiency* AAMD (Clements, 1984: 11-14) divides mental retardation into three categories, such as Severe mental retardation with an intelligence level of IQ less than 30, moderately mental retardation with an intelligence level of IQ ranging from 30-50, and mild mental retardation with an intelligence level of IQ ranging from 50-70.

In Indonesia, ABK can get education through special schools or inclusive schools. Inclusive schools allow students with special needs, including students with the mild mental retardation category recommended by doctors/psychologists to study with regular students. (Irdamurni, 2015).

The existence of an inclusive school aims to provide equal opportunities for every child to get an education regardless of the child's condition (Permendiknas, 2009). Nevertheless, problems or obstacles are still found in the learning process for ABK in inclusive schools, one of which is the limited number of accompanying teachers (GPK) for ABK (Nisa, 2016) and also the perception and understanding of teachers in assisting ABK in inclusive schools. (Efendi et al., 2022; Kubat, 2018). This problem also occurs at SMP N 1 Salatiga. As an inclusive school, in the 2022/2023 Academic Year has two students with special needs, one in the Slow Learner category and the other with Mild Mentally Retartdation. Assistance with ABK in the learning process cannot be carried out optimally due to the absence of the class accompanying teacher (GPK). Schools have managed to involve local authorities, but due to the limited number of companion teachers in Salatiga, GPK cannot routinely assist. This resulted in the learning process of students with special needs in inclusive schools not being optimal, including in learning mathematics. Therefore, it is necessary to assist so that students can improve their mathematical abilities, especially numeracy literacy.

Numeracy literacy is the ability to apply number concepts and arithmetic operations skills in everyday life and the ability to interpret quantitative information around us (Kemendikbud, 2017:3). This ability includes daily abilities such as shopping ability, counting, distance or time, land area, and so on (Baharuddin et al., 2021). One example of numeracy literacy is the ability to value money. The numeracy skills regarding the value of money are also essential for ABK to master (Zuhdi, 2019). Mastery of these abilities can increase the independence that students with special needs have, especially in carrying out daily activities such as during the shopping process to determine the amount of money to pay, determine the amount of change that can be received, etc.

Several studies have been conducted to help ABK students improve their numeracy literacy regarding the value of money. Among them, research by Kusumadewi, (2016) helps the ABK category with mild mental retardation using a shopping learning model in the canteen, and research by Sugino, (2013) also helps ABK with mild mental retardation category by playing a role. Another form of assistance that can be used to assist ABK in learning mathematics is scaffolding.

Scaffolding is assistance specifically made to construct students' abilities, and this assistance can be reduced when it is no longer needed by students (Lindstrom & Sharma, 2011). In line with this, scaffolding is also interpreted as assistance to make a student who is initially unable to complete the task, but in the end will be able to complete the task independently (Maybin *et al*, 1992). Sudrajat (Damayanti, 2016) mentioned scaffolding as systematic assistance according to the conditions of the party being assisted. Moschkovich, (2015) mentioned scaffolding in the form of guidance from adults that refers to one aim by paying attention to time, theory, and concepts.

Several studies have shown how scaffolding can help students with special needs. Among them research by Susilo & Prihatnani, (2022) which applied scaffolding to ABK in the slow learner category for material on integer operations, research of Mahsusiyah, (2014) which applied scaffolding to ABK in the category of Moderate Mentally Retardation for the ability of worship procedures.

Many guidelines can be used as references in providing scaffolding to students, one of which is scaffolding according to Anghileri theory. Anghileri (Kusmaryono et al., 2020) divided scaffolding into 3 stages, such as Environmental Provisions in stage 1. Assistance prepared by the teacher is preparing the student learning environment (classroom organization). Stage 2, Explaining, Reviewing, and Restructuring in which the teacher (aid provider) and students (assisted party) are directly involved in an interaction. The intended forms of interaction include explaining the material, conveying concepts, reviewing, and rebuilding to simplify something abstract so that it can be understood by students. Stage 3, which is the last scaffolding provision according to Anghileri is Developing Conceptual Thinking, namely the interaction between teachers and students aimed at developing conceptual thinking by creating opportunities to express understanding for students and teachers.

This type of scaffolding has proven helpful for students with special needs in increasing numeracy literacy. Research results by Jannah et al. (2019) showed that Anghileri Scaffolding has succeeded in helping students with special needs who experience difficulties in numeracy skills related to number line material.

As well as research by Susilo & Prihatnani, (2022), this research assists ABK in the form of Scaffolding. However, this research focuses on assisting children with special needs in the mild mentally retarded category, not slow learners like research by Susilo & Prihatnani, (2022), this is because it is the ABK category with mild mental retardation who have not mastered numeracy regarding the value of money. In addition, the scaffolding stages that will be used are based on the Anghileri theory because this theory has stages with various alternative assistance. It is hoped that by analyzing the numeracy ability they already have and identifying the inadequacies of ABK, this research can provide the right scaffolding to help ABK to have special numeracy ability related to the value of money. Thus, it is expected that the ABK can have numeracy literacy ability related to the value of money.

METHODS

This research was conducted at SMP Negeri 1 Salatiga, an inclusive school with the research subjects being students with special needs in the mild mental retardation category in the 2021/2022 academic year and registered as class IX students at the school.

This study aims to describe the subject's initial ability (namely students with special needs) regarding the value of money, explore how the thinking process of ABK can be used as the basis for providing scaffolding assistance, and explain how the impact of providing scaffolding has on the subject's ability to the value of money. To achieve the research objectives, qualitative research was carried out, because the focus of the research was to explore the inability of students with special needs in the mild mental retardation category who attended an inclusive school regarding the competence to recognize the value of money, followed by how to provide the right scaffolding, the method chosen in this study was case study method.

The stages in this study were: 1) looking for research subjects with the criteria of students with special needs in the mild mental retardation category who attend inclusive schools who have not mastered numeracy literacy regarding the value of money, 2) exploring the mastery of numeration in the value of money from the selected subjects (identifying abilities, disabilities and way of thinking), 3) designing and implementing forms of assistance (activities/media) that can be provided at each stage of Scaffolding Anghileri according to the needs of the subject, 4) analyzing the impact of providing Scaffolding on the subject's numeracy ability on the value of money.

The data collection process was carried out in a natural setting with data collection techniques emphasizing participant observation techniques (researchers involved themselves to be able to make more in-depth observations), interviews, and test methods.

The technique of checking the validity of the data in this study used several validity tests as follows: 1) Credibility test using the triangulation technique to analyze the credibility of the data in the field and what is reported. Triangulation technique (with three different data collection methods) as well as time triangulation (due to data matching from the data collection process in different periods). 2) The transferability test with the results of this study can later be used as a reference or guide in the process of analyzing the errors of students with special needs and the process of compiling the Anghileri scaffolding for children with mild mental retardation. 3) The dependability test was achieved in this study by 1) observation acuity (based on the researcher's mastery of the theory of the characteristics of students with special needs in the mild mental retardation category, and mastery of material indicators of the value of money, and mastery of scaffolding theory according to Anghileri), 2) analysis process of interview transcripts and video documentation (results from interviews and participant observation processes that occur naturally). 4) Confirmability test with the preparation of research instruments (knowledge test questions, interview transcripts, scaffolding transcripts, classifying errors) was carried out by researchers under the guidance of supervisors who were then verified by two subject lecturers and two related teachers. Furthermore, the research results were processed by researchers with the guidance of lecturers and verification of research results by subject tutors and examiner lecturers.

The data analysis technique used in this study is data reduction, data presentation, and conclusion. In the data reduction process, the researcher categorizes the data, edits the data, and summarizes the data so that the data can be simple than the data obtained during the research. The data analyzed are all learning outcomes in the form of the results of the questions that have been given, interviews, and documentation. After reducing the data, the next thing is to present the data in the form of research results tables which include question indicators, initial abilities, error indicators, the scaffolding stages given and the actions given, and the results. The final stage in the data analysis process is concluding the data.

RESULTS AND DISCUSSIONS

Research Result

Subject Initial Ability

To provide the right scaffolding, data collection and analysis were carried out on the subject's initial abilities. The results of this analysis indicate that the subject can **read**. However, they still have difficulty in **understanding**. This can be seen from the inability of the subject to understand the instructions on the questions. The Subject's inability to understand the questions is also due to the Subject's limitations in understanding the meaning of several terms contained in the instructions, such as the terms "spell out" and "nominal". This inability is classified as a misunderstanding (comprehension).

On that basis, assistance is provided in the form of work examples for each type of question (Figure 1).

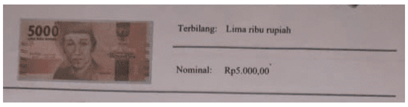

Figure 1. Example of work

This assistance belonged to level 1 scaffolding, namely Environmental Provisions. At this level, the researcher prepared the form of the exercise in such a way that it could help the subject understand the intent/purpose of the problem.

The following is the description of the subject's initial ability, Scaffolding provision, and the subject's final ability in the value of money introduction material.

Indicator 1: "Knowing Types of Money"

Subjects had been able to classify the types of money into paper moneys and coins without having to show actual money. Through the picture of the money given, the Subject was able to classify it into the right type (Figure 2).

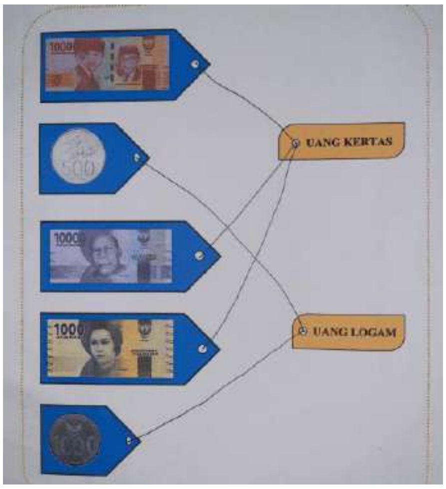

Figure 2. Indicator 1 work results

Indicator 2 "Mentioning and Writing The Value of Money"

The value of money can be expressed in two ways: alphabetical and **nominal**. Alphabetically, the subject could read, mention, and write down the value of money. For example, when the subject saw a figure of a thousand rupiah, they could say and write down the value of the money by reading the information alphabetically (Figure 3).

Figure 3. Information position of money

Nevertheless, the Subject was unable to recognize the value of money because of the inability to mention or write down the value of money when the information about the value of money was removed (Figure 4). This error included the category of transformation. The subject could not transform the information of the value into the form of an alphabet or nominal.

Figure 4. An example of blocking information about money

Therefore, level 2 scaffolding was given with the type of explanation. Explaining was done by providing keywords to give an understanding of the subject regarding the value of hundred and thousand money by providing the following information: 1) there were three zeros (000) which are read thousand 2) while there were two zeros (00) which were read hundreds. This form of keyword did not work when it was just spoken but worked when it was written on the board.

When there were only two zeros, the subject immediately read the leading number and continued with the word hundred. This could be seen when the subject read the two hundred and five hundred money values. As for reading the one hundred, the Subject still read it with one hundred instead of one hundred.

The same scaffolding was given for this type of transformation error, namely by writing the keywords one equal to *use* and the correct and incorrect examples (Figure 5).

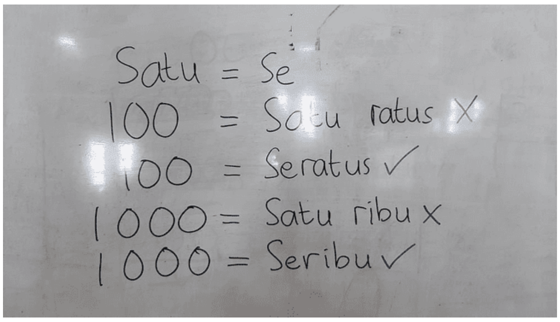

Figure 5. The keyword one is equal to "Se"

Furthermore, in determining the value of money with the types of thousands, tens, and hundreds of thousands, the subject learned by covering three zeros from behind and reading the remaining numbers. For example, when mentioning the value of one hundred thousand, the subject covers it with three zeros from the back and reads the remaining uncovered number (one hundred) and added the thousand to make one hundred thousand. (Figure 6).

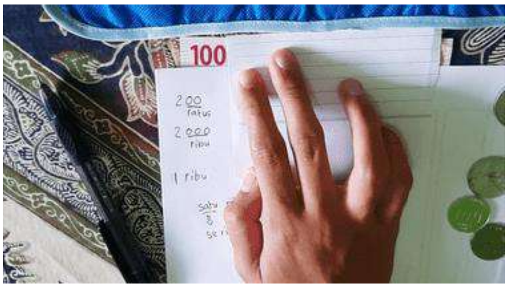

Figure 6. The process of blocking the zeros

In writing the value, the subject did not have difficulty in writing alphabetically because the subject already has acquired writing skills. Even so, the subject still experienced errors (process skills) using capital letters.

This writing error could be seen in Figure 7.

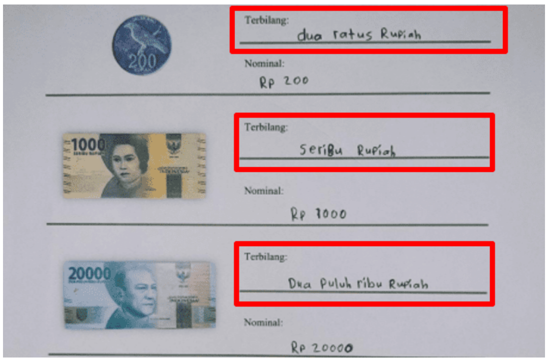

Figure 7. Writing the value of money alphabetically

Even though there were still errors in the writing process (process skills), this study only focused on mathematical abilities and incorrect writing following Enhanced Spelling (EYD).

In contrast to the ability to write down the value of money alphabetically, the subject still experienced an error in writing the nominal amount of money even though an example had been provided. This was because the subject had not understood the procedure for using the rupiah symbol and the dot (.) in stating thousands. This could be seen from the subject's answers in (Figure 8). The subject did not add a comma zero-zero (,00) and did not add a sign (.) as a thousand sign.

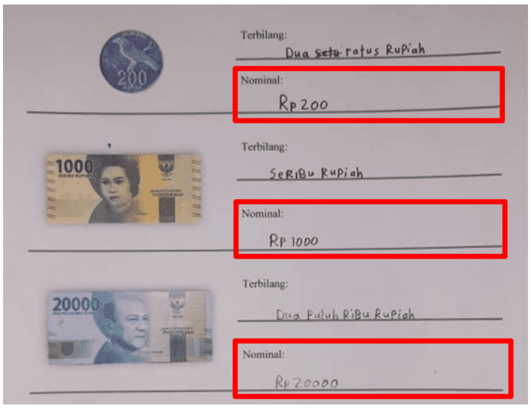

Figure 8. Writing the value of money in nominal

The form of assistance for this type of transformation error was in the form of Scaffolding lv 2, namely Restructuring through the activity of writing values by showing patterns according to the procedure of writing values in nominal terms. The patterns used were: 1) write down the value of money based on the picture; 2) put an "Rp" sign in front of the money value and a zero comma (.00) at the end; 3) add a period as a thousand marker (if needed). The period was added after calculating the 3 zeros from the end of the dollar amount. Each of these steps was demonstrated using a different colored ink (Figure 9).

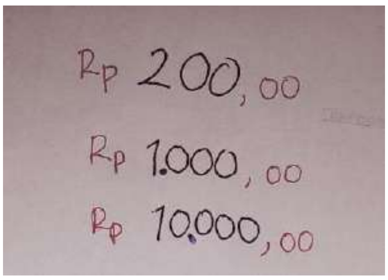

Figure 9. Procedure for writing the value of money in nominal.

Repeatedly, Subjects were asked to practice the procedure also with different colored ink. It was intended to make the subject understand the procedure for nominally writing the value of money. This scaffolding was proven to be able to help in correctly writing the value of money in nominal terms. The correct answers could be seen in (Figure 9).

Figure 9. Nominal correct writing

Indicator 3 "Ordering The Value of Money"

In the indicator of sorting money values, subjects were able to: 1) sort coins from one hundred to one thousand 2) sort one thousand to one hundred thousand paper moneys 3) sort mixed metal and paper money if one thousand notes were paper moneys like (Figure 10)

Figure 10. The sequence of coins and paper money with paper money of a thousand rupiah

However, the subject could not sort it correctly if it contains coins and paper money, especially when there were no thousand paper moneys in it. An example could be seen in Figure 11.

Figure 11. The sequence of coins and paper moneys with a thousand-rupiah coins

The subject always placed ten thousand notes as the first paper money which was arranged after the arrangement of coins. This was due to the Subject's memory that in compiling paper moneys, the first order was money with the first number one so that when there were no one thousand paper moneys, the Subject saw ten thousand as one thousand. This error was included in the Process Skills category.

Due to the incompetence of the Subject, the form of assistance provided was Scaffolding level 3 in the form of a repeat demonstration of sorting money with props starting with the types of coins followed by paper moneys and ending with the combination of the two. When merging with the two, they were given Scaffolding level 2, namely Restructuring by asking the question: "Which money has the same value as this money (the researcher shows a thousand paper moneys)?" The subject succeeded in determining the coin equivalent to a thousand paper moneys by mentioning the value of the money. After the subject understood the similarity in the value of a thousand coins and paper moneys, the subject was asked to sort the money (metal and paper moneys) repeatedly by changing the type of thousand paper moneys. However, this assistance had not been successful. Subjects still experienced failure when there were no thousand paper moneys. The same error was still being made, namely considering the ten thousand as a paper money so that it was placed after the coin. This shows that Process Skill errors were still occurring.

On that basis, level 3 of Scaffolding was given, namely Developing Conceptual Thinking, by reminding the concept of value for money. Subjects were asked to state the monetary value of the money they had arranged. By mentioning the value of the money, the Subject could realize the mistake in the arrangement of money that was made. For example, when the subject was asked to sort the value of money from the smallest. The subject managed to identify the mistake in placing the ten thousand before the two thousand when the subject mentioned the two money values. This was because the Subject already could compare integers where ten was more than two so the Subject could conclude that ten thousand would also be more than two thousand. This checking method was repeated until finally, the subject was able to give the correct sequence. An illustration of this process could be seen in Figure 12.

Figure 12. Checking process in sorting money values.

From this activity, it appeared that the Subject's ability to state the value of money could be used to assist the Subject in sorting money based on its value.

Discussion

The scaffolding award is based on the incompetence and mistakes made by the subject. The identification of subject errors refers to Newman's theory of error analysis (Murtiyasa & Wulandari, 2020; Rohmah & Sutiarso, 2018) which is grouped into 5 types of errors, namely errors in reading, comprehension, transformation, process skills, and encoding. The subject's initial ability is used as the basis for providing scaffolding. Kubat, (2018) said that teachers need to know the level of readiness or initial understanding of students to develop learning methods or strategies.

In this study the subject does not experience reading errors but errors in understanding due to the subject's limitations in understanding the meaning of several terms contained in the instructions. This is the same as found by (Liliani, 2016) in her research which stated that mild mental retardation and ignorance of a term can lead to an inability to understand the reading/problem.

Effective scaffolding can assist subjects in overcoming this problem not by explaining the meaning of terms but by providing examples of work on the questions given. It is as done by Jannah (2019). The existence of examples of working on the questions makes the subject able to independently understand the meaning of the questions given and the subject can work on the questions according to these examples. Therefore, an example of working on the problem in each indicator of the problem is given to clarify the purpose of the problem. Hidayati, (2016) explained that the intellectual limitations of students with mild mental retardation make these students need to provide examples/exemplary in doing something. This is in line with Lei (2018) where one form of Scaffolding is visual Scaffolding which is an aid to students in the form of figures or photos.

The subject also makes a transformation error, namely the inability of the subject to mention and write down the value of money. This is because the subject does not know the value of money. The scaffolding provided is level 2 scaffolding in the form of explaining by involving the concept of integers and giving the keywords "hundred" and "thousand" to overcome the inability of understanding the meaning of the value and the form of restructuring by analyzing the pattern of procedures to assist the subject in writing nominally.

From the scaffolding provided, the researcher finds that the subject can be invited to observe and follow the pattern of a procedure. This is in line with the results of the study by Agustina *et al* (2018) which stated that one way that can be used to train ability for ABK is to provide patterned activities that are carried out repeatedly. This is following the results of the study by Wrona, (2021) which stated that the right type of assistance for ABK students is based on routine (repetitive) activities.

Similar to the research by Saputri, (2017) the subject makes a process skill error. This error is shown by the subject when sorting money based on money values due to being fooled by memorizing the sequence of coin and paper money values. However, the subject can sort money based on its value by reading the number in front of the thousands because the subject can sort positive integers. This shows that ABK can also use logic to think analogously as described in the study by Lambert, (2018). This is also found in research by Labuem (2019) when the subject of ABK students solves the problems posed.

Implications

Based on the research results, the following research implications can be stated: 1) Identifying the types and causes of errors is very important in a lesson; 2) The preparation of an effective scaffolding is a preparation based on the incompetence, errors, and causes of student errors; 3) Scaffolding Anghileri has proven successful in helping ABK in Numeracy Literacy regarding the introduction of the value of money; 4) This research can provide an example to teachers how to explore abilities, disabilities, and develop effective scaffolding.

Limitations

Although in this study the Anghileri Scaffolding succeeded in helping students with special needs in the Mild Mentally Retardation category towards Numeracy Literacy in the Value of Money. However, the results of the error analysis and scaffolding design cannot be generalized to a larger group of subjects. This is because the subjects in this study are limited, namely an ABK in the mild mental retardation category who did not yet have numeracy literacy related to the value of money.

CONCLUSION

Based on the results and discussion, it can be concluded that in solving questions about the introduction of the value of money, the subjects make 3 types of errors, namely comprehension, transformation, and process skills. Misunderstanding occurs when the subject understands the information in the problem. The transformation error occurred due to the subject's inability to mention the value of money and the subject's ignorance of the procedure for writing the value of money in nominal terms. The process skills error occurs when the subject sorts of money based on its value.

In this study, scaffolding that has succeeded in assisting children with special needs in numeracy literacy related to the introduction of the value of money is scaffolding level 1, namely Environmental Provisions, and level 2 with the types of Explaining and Restructuring and scaffolding level 3, namely Developing Conceptual Thinking.

This research has shown that different types of errors can result in different types of appropriate scaffolding. Even for the same type of fault, the scaffolding provided can be different if the causes of the fault are different. Therefore, the researcher suggests that in providing scaffolding to students with special needs, it must not only begin with identifying the location of the error but also proceed with identifying the cause of the error made by the subject.

In this study, the scaffolding provided to ABK is only limited to sorting monetary values and has not yet arrived at monetary equivalence. Therefore, it is suggested that further research can carry out further investigation because the ability to equalize the value of money is needed by ABK in everyday life, for example when processing payment transactions.

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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

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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.

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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

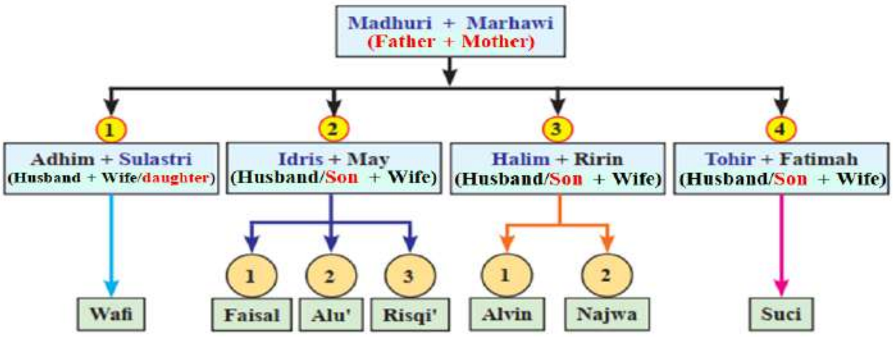

Figure 1. Family Diagram (As'ari, Tohir, Valentino, Imron, & Taufiq, 2017b)

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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