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TABLE OF CONTENT

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STUDENTS PERCEIVED QUALITY OF A SELF-CREATED MATHEMATICS GAME-BASED MATERIALS

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Abstract

This study determined the quality of games students perceived for the game-based materials they develop after they experience playing a mathematics gameboard. The participants in this study were 88 students in 11th-grade Senior High School composed of 40 students in Sohoton General Academic Strand and 48 students in Kanlanuk Technical-Vocational Livelihood, selected through convenience non-random sampling. Through created games by students, it removed the presence of boredom that improved their performance. It impaired other competencies such as retention and automaticity of information from long-term memory. Moreover, students have developed the competitive, cooperative, and meaningful characteristics of the games, which was considered helpful in improving their knowledge based on how they perceived its' characteristics are important to contain in the game, and their confidence to participate in the lessons. Results from the classical item and test analysis spreadsheet revealed that the prior knowledge of the students increased after the interventions were made and implemented. The characteristics of the game were considered helpful to improve students' knowledge and confidence in the lessons. These results have implications for in-depth study and analysis to have conclusive results regarding the influence of the intervention in enhancing students' creativity.

Keywords: Creativity, Game-based materials, Prior knowledge, Problem posing skills, Rubric scoring guidelines.

Abstrak

Penelitian ini menentukan kualitas permainan yang dipersepsikan siswa untuk materi berbasis permainan yang mereka kembangkan setelah mereka mengalami bermain papan permainan matematika. Partisipan dalam penelitian ini adalah 88 siswa kelas 11 SMA yang terdiri dari 40 siswa Sohoton General Academic Strand, dan 48 siswa Kanlanuk Technical-Vocational Livelihood, yang dipilih melalui convenience non-random sampling. Melalui permainan yang dibuat siswa, itu telah menghilangkan hadirnya kebosanan sehingga meningkatkan kinerja mereka. Hal ini merusak kompetensi lain seperti retensi dan otomatisitas informasi dari memori jangka panjang. Selain itu, siswa telah mengembangkan karakteristik kompetitif, kooperatif, dan bermakna yang dianggap membantu mereka meningkatkan pengetahuan berdasarkan bagaimana mereka mempersepsikan karakteristik tersebut penting untuk terkandung dalam permainan, dan kepercayaan diri mereka untuk berpartisipasi dalam pelajaran. Hasil dari spreadsheet analisis item dan tes klasik mengungkapkan bahwa pengetahuan awal siswa meningkat setelah intervensi dibuat dan dilaksanakan. Karakteristik permainan dianggap membantu untuk meningkatkan pengetahuan dan kepercayaan diri siswa dalam pelajaran. Hasil ini berimplikasi pada kajian dan analisis mendalam untuk mendapatkan hasil konklusif mengenai pengaruh intervensi dalam meningkatkan kreativitas siswa.

Kata kunci: *Keterampilan mengajukan masalah, Kreativitas, Materi berbasis permainan, Pedoman rubrik penskoran, Pengetahuan awal.*

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INTRODUCTION

Game-based learning as a concept is structured around a learning process that uses a specific game as the primary pedagogical tool which helps to arise and develop skills (Sousa & Rocha, 2019). For instance, the teaching of Synthesizing Proteins (Cavalho, Beltramini, & Bossolan, 2019) utilizes a board game in providing a symbolic representation of the process of synthesizing the protein through interactions and are guided by the rules where students played the roles of molecules, simulated mechanisms, and processes. These interactions were done in a cooperative and competitive manner that promote meaningful and prospective learning.

DepEd Memorandum No.270 s.2008 (Department of Education Republic of the Philippines, 2008) stipulated to teachers are encouraged to develop a sustainable strategic intervention in the fields towards gearing up for global competitiveness. In the work of Crespo and Sinclair (2008), they presented an intervention approach explicitly problem posing, where students acquire new concepts and ideas in Mathematics based on a given situation. This approach helped students develop their ability to solve higher mathematical problems that are related to the questions they formulated.

On the other hand, when students presented the mathematics concepts which are cognitively structured that develop higher levels of thinking, they usually cannot focus and easily get bored when working with these problems (Brown, Brown, & Bibby, 2008; Lazarides & Buchholz, 2019).

Considering the situations mentioned above, there is a need of developing an intervention approach in teaching to remove the presence of boredom and help improve students' performance. In this paper, this intervention can be used for developing the competencies and problem posing skills of the students. This skill creates new problems for investigating a given situation as well as reformulating a problem during its solving process by Shafie, Shahdan, and Liew (2010). Furthermore, this problem posing skill is relevant to the mentioned situation, it was the students formulate or make a question about the given situation and then they solve it as Asfaroh and Ekawati (2019) claimed in their study. The study was conducted through pre-solution posing which focused on making questions based on the situation or information that will provide an open problem that can develop students' mathematical connections. Apart from that, a semi-structured situation is one of the situations on problem posing that ask students to pose a problem from an

open condition which has a chance to be completed by applying prior mathematical knowledge or concepts. Through the use of games in teaching Mathematics, concepts such as the four fundamental operations and inequalities, exponentiation, and taking the square root of the numbers may improve the students' retention level and enjoy the process of learning. Although it may sound a bit basic for the students that teaching these concepts, especially for the higher level, e.g., 11^{th} grade, this is important since learning higher Mathematics requires the mastery of the basic operations. Recently, Fischer et al. (2019) argued that teaching these operations are important since there is a negative consequence of the possibility of using calculators, tablets, and computers in Mathematics classroom. Although it is easier to get a value when using such technology, it could impair other competencies such as retention and automaticity of retrieval of information from long-term memory.

On the other hand, students' creativity in creating games will be assessed through a problem posing approach. This approach is based on developed the problem posing structure by Brown and Walter (2005) and it will be used for the development of educational-related games.

Conceptual Framework

Game-based learning is based on the integration of games into the classroom to create a level of motivation and achievement (Becker, 2017). A number of studies revealed that these games have a positive effect on students' education since they empower their engagement and attitude toward the lesson content (Blunt, 2009).

Jean Piaget's theory of constructivism offers a window into what students are interested in and able to achieve at different stages of their development. Also, it argues that students produce knowledge and form meaning based on their experiences. This theory also provides a roadmap for teachers, especially in Mathematics to help children's cognitive development by applying games to get better knowledge (Ojose, 2008).

In this matter, game-based learning is built upon a constructivist type of learning. Wherein, constructivism posits the need to provide students with necessary tools such as games so they can build their own procedures in order to solve a mathematical problem. This implies a participatory process by students, who interact with their environment to solve the situation that is being set out to them in order to learn.

However, learning may occur in a variety of locations such as schools, classrooms, laboratories, fields, and so on. Learning environment not only refers to physical locations but also encompasses learning resources and technology such as game-based materials. This learning material may be considered as a new environment for the reason that the students learned a new way of the learning process where this material helps to enhance and motivate students' interest and understanding and develop students' knowledge and skills in mathematics.

Accordingly, learning through games allows any person to accommodate the new environment, overcome obstacles, and reach balance again (Becker, 2017). Becker also identifies that in the 21st-century students are no more accustomed to the drill and practice strategies. They build their individual learning at their own pace and evolve it to cover the deep learning process by enhancing the retention of the concepts. Nurturing structured problem posing ability can enhance creativity. These characteristics help those students develop games since the game requires a certain level of creativity and interactivity.

The theories mentioned above, students determined the characteristics of the game that they considered helpful such as competitive (Menesini, Tassi, & Nocentini, 2018) where the students improve their teamwork and collaboration, enhance social and emotional learning, increase respect for academics and interest in learning, increase intrinsic motivation, enhance beneficial peer comparisons, and strengthen academic self-concept, cooperative (Atxurra, Villardon-Gallego, & Calvete, 2015) where it helps to raise students' achievement, build positive relationships among students which are important for creating a learning community that values diversity, and provide experiences that develop both good learning and social skills, and meaningful (Spooren, Mortelmans, & Denekens, 2008) where it helps to stimulate the learner to bring in a lot of prior knowledge and personal experience that makes the learning more meaningful and to reinforce the learning and improves long-term memory. These characteristics serve as a tool for the students to develop game-based materials.

Students' creativity in creating games was assessed through a problem posing approach. This approach of creating a game is based on the developed problem posing structure approach by Brown and Walter (2005), in which students developed constructive learning based on the work of many psychologists and educators like Jean Piaget, Jerome Bruner, and Lev Vygotsky (Saad, 2014). It builds on prior knowledge and

connects it to the new information; thus, the students apply personal learning (Dewey, 1916; Von Glaserfeld, 1987) where learning is produced in the context of constructivism, in which the problem posing approach was applied through their experiences and learning in playing the game. These are the reasons that the students develop their own games. This works on the initial function of the mind where it creates and views things in chronological order (Piaget, 1971). Robinson (2004) supports the work of Piaget (1980) that getting older changes the minds' conceptualization, especially through experimentation. This testing gives students a credit in full understanding without forgetting the experiment (Piaget, 1980). In addition, Vygotsky and Cole (1978) established a "zone of proximal development" in which the student depends on others' teaching to reach full understanding.

The theory mentioned fits in this research since students enthusiastically form on their prior knowledge, and get support from one of the advanced students. This is to achieve the goal when students face new knowledge and encounter it with existing ones. Saad (2014) affirms Cooper (1993) about constructivists assure that learning is deep-down and inspiring accompanied by problem posing and investigating. They considered that the students build their personal education based on lively investigations and become active students when placed in a real-world environment.

Research Problems

This study determined the quality of games that students perceived for their developed game-based materials after they had experienced playing mathematics boardgame. Specifically, it provided answers to the following:

1. What is the level of students' prior knowledge in terms of the following operations: (a) addition, (b) subtraction, (c) multiplication, (d) division, (e) inequalities symbols such as < and >, (f) exponentiation, and (g) taking the square root of a number?
2. After the first intervention, how did the students evaluate the value of games in connection to their knowledge of the mentioned operations on problem 1?
3. To what extent are the following characteristics of the game that students considered helpful in terms of: (a) Competitive, (b) Cooperative, and (c) Meaningful?
4. From the students' developed criteria, what scoring guide can be developed?
5. What are the games developed by the students based on the games they encountered?

RESEARCH METHODS

In gathering the needed information and data, the researcher will utilize a single case design Riley-Tillman, Burns, and Kilgus (2020) particularly the B-design. The design is a descriptive one, unlike the experimental single case, the single case will only provide correlation rather than effect since there were other variables not measured in the study that might cause the results to improve. There were 88 students who participated in this study who are composed of 15 males and 25 females a total of 40 students in Grade-11 Sohoton General Academic Strand (GAS) and 28 males and 20 females a total of 48 students in Grade-11 Kanlanuk Technical-Vocational Livelihood (TVL) of a Senior High School were the study is conducted.

The scheme visualized the research procedure to answer problems for this study is shown in Figure 1.

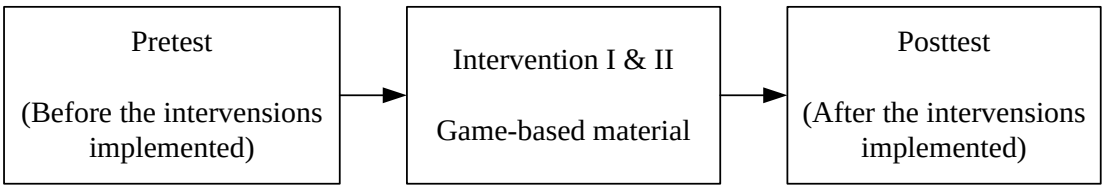

Figure 1. Research procedure's scheme

Based on Figure 1, a pretest had been conducted before the interventions were implemented. It was to measure the students' prior knowledge in the following terms such as addition, subtraction, multiplication, division, inequalities such as < and >, exponentiation, and taking the square root of a number. During the interventions, students evaluate the value of games in connection to their knowledge of the operations mentioned in problem 1, determine the characteristics of the game considered helpful (the category refers to Table 1), develop a scoring guide based on how students perceived the important criteria and their developed new criteria, develop games and then the mathematics teachers use their developed criteria to judge the games they developed based on the game they previously encountered.

After the interventions had been implemented, students were given a break of weeks before the posttest will be conducted. To determine if students' knowledge improved through the implemented interventions, the difference between the pre and posttest will be compared. Through students' experiences had been playing the introduced games by their teacher, the 88 students who participated in this study developed their own games.

As a matter of fact, in their developed games, it is also developed their competencies in mathematics and a problem posing approach to help them gain a competitive advantage globally. Also, through using these games, concepts such as the mentioned operations in the problem are highly improved in terms of their retention and enjoyment in the process of learning.

Tabel 1. Scale for characteristics of the game

Scale	Verbal Interpretation (VI)	Qualitative Description (QD)
1 – 1.75	Strongly Disagree (SD)	Very Low (VL)
1.76 – 2.5	Disagree (D)	Low (L)
2.51 – 3.25	Agree (A)	High (H)
3.26 – 4	Strongly Agree (SA)	Very High (VH)

RESULTS AND DISCUSSION

Table 2 shows the level of knowledge of the students of the same type of questions and number of test items as tabulated and interpreted in a pretest where the mean and standard deviation of addition, subtraction, multiplication, division, inequalities such as < and >, exponentiation, and taking the square root of a number are as follows: 0.90(0.70), 2.26(1.00), 1.89(0.75), 3.18(1.52), 0.82(0.70), 2.74(1.34) and 1.16(0.69), where the average mean and standard deviation is 13.50(4.27) indicating that the level of student's knowledge is "low".

Table 2. Level of Knowledge in Pre and Post test

Level of Knowledge in terms of	Pretest		Posttest		Diff.
	$\overline{X}$	*SD*	$\overline{X}$	*SD*	
$+$	0.90	0.70	2.60	0.62	1.70
$-$	2.26	1.00	3.65	0.57	1.39
$\times$	1.89	0.75	2.72	0.55	0.83
$\div$	3.18	1.52	5.38	0.85	2.20
$<,>$	0.82	0.70	1.63	0.59	0.81
X^2	2.74	1.34	4.57	0.71	1.83
$\surd$	1.16	0.69	1.58	0.62	0.42
Average	13.5	4.27	22.1	2.98	8.61

Also, the minimum and maximum are 12 and 32 in the level of students' prior knowledge test where the scale is also used in students' gain knowledge test. Whereas, the mean and standard deviation of students' knowledge in terms of addition, subtraction, multiplication, division, inequalities such as < and >, exponentiation, and taking the square root of a number in posttest are as follows: 2.60(0.62), 3.65(0.57), 2.72(0.55),

5.38(0.85), 1.63(0.59), 4.57(0.71) and 1.58(0.62), where the average mean and the standard deviation is 22.11(2.98) indicating that the level of student's knowledge is "high". Also, the minimum and maximum are 16 and 25 in the level of students' gain knowledge test. The difference mean scores of students' knowledge in terms of as mentioned above are as follows: 1.70, 1.39, 0.83, 2.20, 0.81, 1.83, and 0.42 with an average mean of 8.61 indicating that the games help students to improve their knowledge. As a matter of fact, students' knowledge with the highest average mean (*M*= 22.11, *SD*= 2.98) was described as "strong proof" that their knowledge highly increases through their developed games. Meanwhile, the lowest average mean (*M*=13.50, *SD*= 4.27) was described as "proof" that the teacher let his students develop and play educational games.

Thus, with the highest mean where students preferred to develop and play educational games, this only means that the students improve their retention and enjoy the process of learning. While this remains an advantage, there is also an advantage in terms of the students' problem posing skills through playing educational games. Teachers helped their students to develop creativity through games.

This simply corresponded that students develop their ability to solve higher mathematical problems that are related to the questions they developed while creating/developing and playing educational games instead.

The students were evaluated by the value of games through the games' characteristics that have been considered helpful to their learning. These games' characteristics were competitive, cooperative, and meaningful. The mean and standard deviation of these characteristics have been computed by students' evaluation in their statements about how the description of the game is related to the three characteristics, it is shown in Table 3.

Table 3. Extent of the Characteristics of the Games that Considered Helpful

Characteristics of the Games	$\overline{X}$	*SD*	QD	VI	Rank
A. Competitive	3.364	0.426	VH	SA	2
B. Cooperative	3.390	0.442	VH	SA	1
C. Meaningful	3.348	0.444	VH	SA	3
Average	3.367	0.432	VH	SA	

Table 3 showed that respondents agreed with "strong conviction" of the characteristics of the games that are considered helpful. In fact, the overall mean of 3.367 (*SD* = 0.432) indicates that participants "strongly agree" that these characteristics helped students to boost their knowledge as well as their confidence in terms of the operations

mentioned in problem 1.

From the developed criteria by students, they developed the rubric scoring guidelines for the games. In fact, it is important for students able to evaluate their existing knowledge and skills. The developed guidelines are about the terms of defined criteria by them, and they included themselves in the evaluation process.

The developed games by students is the mathematical board game based on the games encountered themselves.

Findings

The findings are as follows. (1) The student's results from the pretest, according to Fischer et al. (2019), showed that their scores on the items are moderately high, that is, out of 40 items the average score is about 24. It means that students' prior knowledge about the used contents in the test is on the average level. (2) Students developed a scoring rubric, according to Ak (2012), it is about how they perceived a game to be useful and effective. These developed rubrics were used by the teachers for evaluating the created games by students after students experienced playing the game. The characteristics of the game were considered helpful to students such as competitive by Menesini et al. (2018), cooperative by Atxurra et. al. (2015), and meaningful by Spooren et. al. (2008). Although they did not explicitly describe what is meant by meaningful. (3) The developed games by students had little variation rather than the original game encountered them. They just added simple colors, the "emoji" or images of faces. Students used common emojis which can be found in social media as a reaction to the created post by platform members. (4) Varying the games' elements by students' creation through the problem posing approach did not help much to their developed games. (5) The developed games by students did not show much creativity since the original form of the games almost reflects the same form of their experienced games if it was compared to their creations.

CONCLUSION

Based on the findings presented in this study, it is concluded that: (1) The games removed the presence of boredom in order to improve students' performance. Also, it impaired other competencies such as retention and automaticity of information from long-term memory. (2) The students found appreciation and meaning for the played games, but it did not transform into the level where they can apply. While this remains an advantage,

there is an advantage also in terms of the suitability of games' characteristics with students' needs for learning. (3) The characteristics of the game such as competitive, cooperative, and meaningful were considered helpful to improve students' knowledge based on how they perceived the important characteristics to be contained as well as their confidence to participate in the lessons. The explicit meaning of these concepts was not given or explained further by the students. (4) The scoring guideline not only helped students to evaluate the parts and products of the developed games by them but also the teachers evaluated the games. Thus, it demonstrated that the students made evaluations as "good". (5) The students developed board games for improving their competencies in Mathematics by using the problem posing approach, it did not vary much from the original games, hence, creativity was not enhanced. The developed games by students almost replicate with they encountered in the previous game.

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ANALYSIS OF STUDENTS' MATHEMATICAL UNDERSTANDING ON ARITHMETIC SEQUENCES AND SERIES IN 12th GRADE SENIOR HIGH SCHOOL

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Abstract

The purpose of this study was to analyze students' understanding to solve arithmetic sequences and series questions. The subjects of this study were students who are in the 12th grade at SMAN 2 Garut, and they were 77 persons has been selected randomly from two study groups with the same teacher. This research applied descriptive quantitative techniques. The research result shows that students' ability is still low in solving arithmetics questions. This research found that there are three categories of students based on their achievement scores, namely the low category with a percentage is 42%, the medium category with a percentage is 36%, and the high category with a percentage is 22%. Some factors causing students' errors are ineffective learning, uncarefully solving questions, and students have been lack of understanding of the material.

Keywords: Arithmetic, Sequences, Series, Students' understanding.

Abstrak

Tujuan penelitian ini adalah menganalisis pemahaman siswa dalam menyelesaikan soal materi barisan dan deret aritmetika. Subjek penelitian ini adalah siswa kelas XII di SMAN 2 Garut yang terdiri dari 77 siswa responden yang diambil dari dua kelas secara acak dengan pengajar yang sama. Pendekatan penelitian ini adalah deskriptif kuantitatif. Berdasarkan penelitian menunjukkan bahwa kemampuan siswa masih rendah dalam menyelesaikan soal materi ini. Hasil penelitiannya terdapat tiga kategori siswa berdasarkan nilai capaiannya yaitu kategori rendah dengan persentase 42%, kategori sedang dengan persentase 36%, dan kategori tinggi dengan persentase 22%. Faktor yang menyebabkan timbulnya kesalahan tersebut adalah pembelajaran kurang efektif, kurang teliti dalam mengerjakan soal, dan kurangnya pemahaman siswa pada materi.

Kata kunci: *Aritmetika, Barisan, Deret, Pemahaman siswa.*

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INTRODUCTION

Some students have considered mathematics is a difficult subject to be understood (Azizah, Maharani, & Suprapto, 2022). The reason was mathematics is about numbers, formulas, and counting principles (Hariyomurti, Prabawanto, & Jupri, 2020). Even though mathematics has many benefits in their life. Originally, mathematics comes from Greek, *mathematike*, that means studying (Monalisa et al., 2022; Beziau, 2020). The

original word is *mathema*, it means knowledge or science. The word of *mathematike* is also related to other words, it is almost the same word, namely *mathein* or *mathenein*, that means learning to think (Azka, Mintarsih, & Ruqoyyah, 2018; Istihapsari, Rochmad, & Isnarto, 2021). It can be concluded that mathematics is knowledge from thinking or reasoning.

Mathematics subject discusses arithmetic series and sequences. A sequence is a set of numbers, they are ordered according to certain rules or pattern, and the series is the sum of the sequences (Darmayanti, Sugianto, & Muhammad, 2022). Arithmetic is a branch of mathematics about the basic operations on numbers. Thus, the meaning of an arithmetic sequence is a sequence of numbers with a certain pattern, and they have the same difference, so the arithmetic series is the sum of an arithmetic sequence.

The arithmetic sequences and series are material for 11th-grade senior high school students to learn in the Indonesian curriculum (Sari & Susanti, 2020; Kindangen, Sulangi, & Damai, 2021). This research selected this material because they have had a mathematical understanding ability in low relatively, like some study reports such as Azizah et al. (2022), Silaban, Simbolon, and Lumbantoruan (2022). This material is included in the examination for admission to some Universities, so students must be understanding arithmetic sequences and series, especially if they are in 12th-grade high school.

Each student has a different ability to understand for solving a mathematics problems. There were some students who find difficulties understanding arithmetic sequences and series materials. The difficulties happened when they were working on a mathematics question by inappropriate steps to solve. It was because students memorize formulas as usual without understanding the concepts of arithmetics material they have been learned. Therefore, this research is to analyze how students solve questions about arithmetic sequences and series with the specific design. This research so that they can analyze how well students understand the material. This study is useful to find out how students understand arithmetic series and sequences, and how mastery they are.

RESEARCH METHODS

The research method used is a quantitative descriptive research method. Quantitative descriptive research method is a method that aims to create an objective picture or

description of a situation using numbers, starting from data collection, interpretation of the data as well as the appearance and results (Arikunto, 2010). Quantitative data was obtained through the results of tests on the comprehension abilities of class XII students at SMAN 2 Garut in solving questions regarding Arithmetic Sequences and Series with a total of 77 students. Data collection was carried out by distributing questionnaires via Google forms which contained 15 multiple choice questions regarding the scope of the material.

The research method was carried out aiming to find out the results of students' understanding ability test scores, provide the score criteria obtained, and analyze difficult questions and easy questions. Therefore, the research method used is in accordance with the objectives of the research conducted.

RESULTS AND DISCUSSION

Research activities are carried out online through the WhatsApp Group by distributing questionnaires via the Google form. The implementation of the competency test for understanding the material for Arithmetic Linears and Sequences aims to determine the ability of class XII students at SMAN 2 Garut in working on these material questions. This competency test was shown to class XII students, totaling 77 students.

After students submit the results of the competency test, students will get the results of the score made by the researcher and the answer key that has been made by the researcher. Obtaining student answers are used by researchers to determine the value category and to determine the types of difficulties experienced by students. Researchers create value categories, namely low, medium and high according to the scores of students' scores with the aim of calculating the percentage of students. The following is a table of student scores according to their categories and percentages.

Table 1. Student Scores

Category	Student Scores	Total Student	Percentage
High	71-100	17	22%
Medium	36-70	28	36%
Low	0-35	32	42%

Based on Table 1, it is known that the average (*M*) is 44.8, the mode is 73.3, the median is 20. These descriptive statistics serve as a reference for the category of student scores in the high clarification (score 71-100), moderate (value 36 -70), low (value 0-35).

Thus it can be obtained that the percentage of student scores is 42% in the low category, 36% in the medium category, and 22% in the high category. The first, 42% of the data are students who get low scores. The number of students who got low scores was 32 students. This shows that out of 77 students, more students get low scores. So many students are unable to solve problems on arithmetic sequences and series material. Second, 36% of the data are students who get moderate scores. The number of students who get moderate scores is 28 students. This shows that most students can answer the questions because they are based on the results of the scoring categories. Third, 22% of the data are students who get high scores. The number of students who got high scores was 17 students. In this case it shows that only a few get the highest score.

After getting the results of student scores, the next step is to examine the answers of the students. The students' answers were analyzed, so that they could find out the students' comprehension skills in solving Arithmetic Sequences and Series questions. The number of questions that the researcher gave was 15 questions which contained 3 categories of questions, namely basic questions, story questions, and UTBK questions. The following are the results of the answers of students who got the correct answers and those that match the types of questions given.

Table 2. Student Answers

Question Type	Question Number	Total Student	Percentage
Basic Question	1	62	81%
	2	37	48%
	3	52	68%
	4	46	60%
	5	40	52%
Story Question	6	36	47%
	7	24	31%
	8	48	62%
	9	26	34%
	10	37	48%
UTBK Question	11	39	51%
	12	24	31%
	13	25	33%
	14	14	18%
	15	8	10%

Based on Table 2, the types of questions that received the highest number of correct answers were the basic questions contained in question number 1 of 62 out of 77 students

with a percentage of 81% who answered correctly. Problem number 1 is considered the easiest problem because the questions given are the most basic questions regarding arithmetic sequences and series. In accordance with the assumption of the researcher that question number 1 is one of the easiest questions. Meanwhile, the type of questions that received the highest number of errors was in the UTBK questions contained in question number 15 as many as 8 out of 77 students with a percentage of 10% who answered correctly. Question number 15 is considered the most difficult because the questions given are questions that take a long time to work on with lots of formulas and make students think logically. In accordance with the assumption of the researcher that question number 15 is one of the most difficult questions.

For the results of student answers obtained there are questions with the highest number of correct and incorrect students. The following is an analysis of question number 1 which causes students to be able to solve the problem.

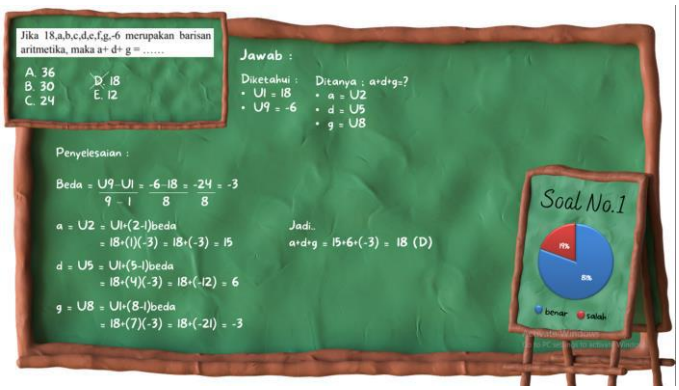

Figure 1. Problem Number 1

Based on Figure 1, question number 1 belongs to the basic type of question, because this question is about an arithmetic sequence where students have to find the value of each term first in order to get the result of $a+d+g$. First, students must determine what is known and asked in order to make it easier for students to work on the questions. Second, students can find the different value of each term with the formula for the value of the last tribe minus the value of the first tribe, then dividing the last term minus the first term, you will get the different value of each tribe. Third, students can find the value of each term with the formula $U_n=a+(n-1)b$. After getting the value of each term, students can get the result of $a + d + g$. It can be concluded that question number 1 is the easiest of all the questions given by the researcher.

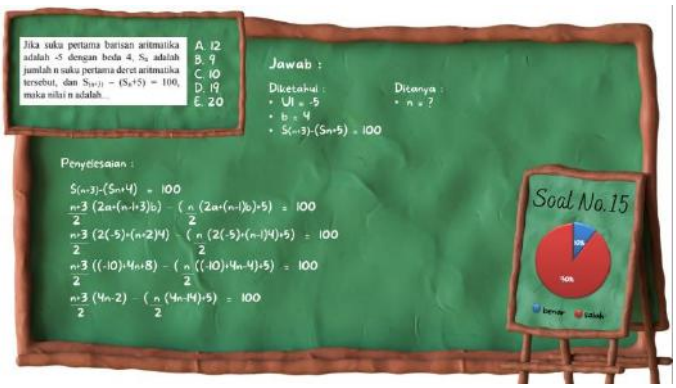

Figure 2. Problem Number 15

Based on Figure 2 and Figure 3, question number 15 is included in the UTBK type of question (Ayam, 2022), this question concerns an arithmetic sequence where students have to find the value for every n of the equation $S_{(n+3)}$-(S_n+5)=100. First, students must determine what is known and asked in order to make it easier for students to work on the questions. Second, students can substitute the formula S_n=n/2(2a+(n-1)b) into the equation $S_{(n+3)}$-(S_n+5)=100. Third, students can simplify the equation $S_{(n+3)}$-(S_n+5)=100 which has been substituted with S_n=n/2(2a+(n-1)b) until the value of n is known. It can be concluded that question number 15 is the most difficult of all the questions given by the researcher.

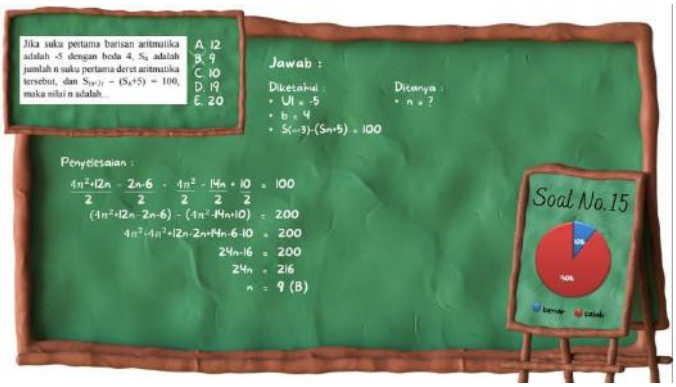

Figure 3. Problem Number 15

From the results of the data that have been grouped and analyzed, it is concluded that: (a) The average student score is 44.8. This indicates that the average student score does not meet the KKM standards set by the school, namely 70; (b) Only a few students who scored at intervals of 71-100 were included in the high category, namely 17 out of 77 students with a percentage of 22%; (c) The highest score obtained by students is in the

interval 0-35 which is included in the low category, namely 32 out of 77 students with a percentage of 42%.

Based on the results of the tests that have been carried out, the researcher can analyze the difficulties experienced by students and the abilities possessed by students in working on material problems of arithmetic sequences and series. The difficulty that is often experienced by students when working on questions is the steps that are not appropriate in working on these questions. The results of this study are relevant to several findings (e.g. Silaban et al., 2022; Wulandari & Setiawan, 2021; Annisa & Kartini, 2021) that a high percentage of students who experience difficulties has the same meaning as a low percentage of students who understand the material.

Previous researchers only analyzed students' understanding of the material which consisted of several categories. Therefore, in addition to dividing students according to the categories of values obtained, the researcher also added data that was in accordance with the research objectives, namely by analyzing several questions which included easy and difficult questions according to students obtained from the results of the data that the researchers had made. By analyzing a number of questions, the researcher can determine the level of students' ability to understand the material for arithmetic sequences and series by working on these questions.

CONCLUSION

Based on the research that has been done, obtained data and information, as well as the analysis that has been carried out on the data and information, it is obtained that students' understanding of the material for arithmetic sequences and series describes the three categories of student scores, namely, students with low scores as much as 42%, students with moderate scores as much as 36% and students with high scores as much as 22%. The 4 factors that cause difficulties in understanding the material for arithmetic sequences and series experienced by students are: (1) the learning process is less effective, (2) not careful in working on questions, (3) students' lack of understanding of the material.

From the results of this study it can be concluded that an ineffective learning process is the main factor in students' difficulties in understanding the material being taught. This shows that at the learning stage students have experienced difficulties in understanding the material so that students will have difficulty at a later stage.

Based on research on understanding mathematical material regarding arithmetic sequences and series that has been carried out on class XII students of SMAN 2 Garut, suggestions that can be given by the author are: (1) for teachers, teachers should be able to streamline the learning process by providing innovation in learning methods in class so that the learning atmosphere becomes fun for students which can increase students' understanding of the material being taught. (2) for students, students should not only rely on the learning process at school in understanding the material. But it would be nice if students also look for alternative learning outside of school to support learning so that they can still explore the material taught at school and understand it.

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Completion of this journal could not be separated from the help and participation of various parties. Therefore, the authors would like to express their sincere gratitude to the class XII students of SMAN 2 Garut who are willing to take the time to participate in this research activity. As well as all parties who have supported this research activity. Hopefully this article is useful and becomes a reference for related parties.

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DEVELOPMENT OF WORKSHEETS BASED ON THE METAPHORICAL THINKING APPROACH FOR STUDENTS' PROCEDURAL FLUENCY ABILITY

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Abstract

The mathematics materials in learning mostly used package books, but the provided resources in the school were limited and teachers did not optimize the existing technology to provide effective and interesting materials. As a consequence, students did not complete the exercise according to mathematical procedures and they were pessimistic. The general research purpose was to produce a metaphorical thinking approach-based worksheet for students' procedural fluency on valid characteristics. This study used research and development by the ADDIE stage model. The participant was 9th-grade students in junior high school. Data collection were observation, questionnaires, and interview techniques. The results showed that the characteristics of the developed worksheet have been valid. The results of the worksheet validity test were obtained by 90% and the results of the trial of students were 93%. The implications of this worksheet are helpful for students to independent learning, and this worksheet helps students solve mathematical problems in accordance with procedural, assisted by steps of the metaphorical thinking approach, teaching and learning activities are more effective.

Keywords: Metaphorical thinking approach, Procedural fluency, Worksheet development.

Abstrak

Materi matematika dalam pembelajaran paling sering bersumber dari buku paket, namun jumlah yang tersedia di sekolah terbatas dan guru tidak mengoptimalkan keberadaan teknologi untuk memberikan materi yang efektif dan menarik. Akibatnya, peserta didik tidak menyelesaikan latihan sesuai prosedur matematika dan mereka pesimis. Tujuan penelitian secara umum adalah menghasilkan Lembar Kerja Peserta Didik (LKPD) berbasis pendekatan berpikir metaforis untuk kelancaran prosedural mereka pada ciri-ciri yang valid. Penelitian ini menggunakan penelitian dan pengembangan dengan model tahapan ADDIE. Pesertanya adalah peserta didik kelas 9 di Sekolah Menengah Pertama. Pengumpulan data dilakukan dengan teknik observasi, angket, dan wawancara. Hasil penelitian menunjukkan bahwa karakteristik LKPD yang dikembangkan sudah valid. Hasil uji validitas LKPD diperoleh sebesar 90% dan hasil uji coba peserta didik sebesar 93%. Implikasi dari LKPD ini adalah membantu peserta didik untuk belajar mandiri, dan LKPD ini membantu peserta didik memecahkan masalah matematika sesuai dengan prosedural, dibantu dengan langkah-langkah pendekatan berpikir metaforis, kegiatan belajar mengajar lebih efektif.

Kata kunci: *Kelancaran prosedural, Pendekatan metaphorical thinking, Pengembangan lembar kerja*.

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INTRODUCTION

Mathematics is one of the subjects taught at every level of school, both elementary school, junior high school, senior high school to higher education. Through mathematics education, students are expected to become human beings who are able to think logically, conscientiously, carefully, critically, creatively, innovatively, imaginatively, and hardworkingly (Pratidiana & Muhayatun, 2021). The purpose of education is to identify and develop the existing creativity and potential innovations of each individual (Lai et al., 2019). In this case, it is very necessary that there is a learning of mathematics in schools. Teachers often face difficulties in applying thematic learning (Retnawati et al., 2017). Various efforts have been made to improve the quality of education, including the establishment of eight national education standards. In this case, it is very necessary to have mathematics learning in schools (Rashidov, 2020). One of the causes of low student achievement in mathematics learning is the learning process that includes cognitive and psychomotor abilities that are not optimal (Apertha, Zulkardi, & Yusup, 2018).

One of the cognitive aspects that must be mastered by students is mathematical procedural fluency (Zebua & Waruwu, 2022). Mathematical procedural fluency is the ability of students to choose and use appropriate procedures to solve a mathematical problem, without adequate procedural fluency, learners will have difficulty in deepening their understanding of mathematical ideas or solving mathematical problems (Phuong, 2020). The indicators of mathematical procedural fluency include choosing the right procedures to solve mathematical problems, using procedures that have been selected, utilizing procedures, modifying or improving procedures (Firdaus, 2019).

Based on observations by researchers to the 9^{th} grade students in Madrasah Tsanawiyah (MTs) IT Bany Zuhud Wanasalam, learning classroom had been still teacher-centered, students tend to passively only listen and pay attention when the teacher explains the lesson in class. Few learners ask questions when given the opportunity to ask questions. Then students are asked to do practice questions related to the material presented, they find it difficult to do the practice questions independently because students are not used to it and always need help from the teacher. This is an activity that shows the characteristics of students not being able to learn independently and is very teacher-centered. Students do not yet know how to use the right procedures,

make good use of procedures and the lack of teaching materials are the main factors in them not being able to learn independently and try to solve the mathematical problems they face. Learning in this way really requires additional learning media if in the learning process there is only one learning resource, namely the teacher. As shown in Figure 1, learners have not been able to choose and use the procedure.

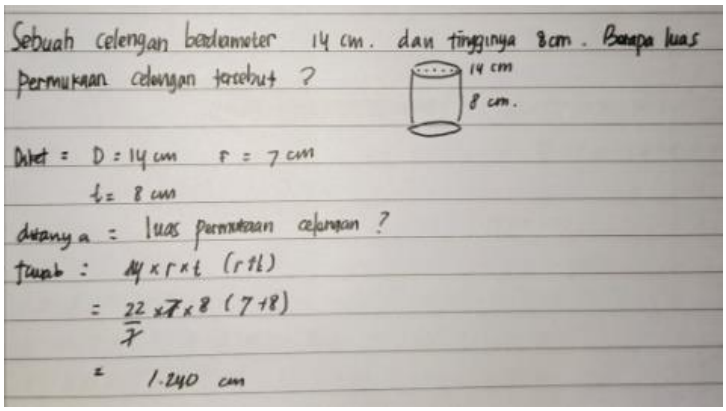


Figure 1. Student Work Results

One of the determining factors for the success of learning in the classroom is the use of learning media (Lisnawati, 2021; Syakur, Sugirin, & Widiarni, 2020). The urgency of using learning media as a learning tool is to help educators convey messages and learning materials to students effectively and efficiently (Pratama & Saregar, 2019). Therefore, it is necessary to select learning media that are in accordance with the needs, in order to achieve learning objectives.

Based on the results of interviews with mathematics teachers and the 9th grade students in MTs IT Bany Zuhud Wanasalam, the teaching materials used by the teachers are only sourced from package books provided from schools and the number is not comparable to the number of students. This causes students to only have explanations from the teacher, students tend to memorize the concepts learned instead of understanding so that when given practice questions they still need direction from the teacher. In addition to teachers' hard-to-remember explanations, the lack of learning media that can help lead them to solve math problems independently. Resulting in teachers feeling difficult and hampered in achieving learning goals. For this reason, teachers need other solutions so that learning activities run more effectively, such as additional teaching materials for teachers and students to make observations, ask questions, reason and so on. Thus, students' insights are not only in one material.

One form of visualization that can be done is through the students' worksheet. The purpose of using students' worksheet in the learning process is to strengthen and support learning in achieving indicators and competencies in accordance with the curriculum (Huda, Anggraeni, & Supriatno, 2020). Students' worksheet is defined as printed teaching materials in the form of sheets of paper containing tasks, implementation instructions, and steps for completing tasks on a certain material that must be done by students with reference to basic competencies and indicators that must be achieved (Jusmawati et al., 2021). The developed students' worksheet by the Researcher was designed to be as attractive as possible with language that is easy to understand the 9^{th} grade students to foster the enthusiasm and motivation of students to learn it then combined with a metaphorical thinking approach that is able to overcome student learning problems, especially for problems of procedural fluency of students.

According to Hendriana (in Hasnarika, 2022) suggests that the metaphorical thinking approach is a bridge between model and interpretation, providing great opportunities for learners to exploit their knowledge in learning mathematics. Metaphor is the concept of thinking from an object or idea that has been known before to another unknown idea (Robutti et al., 2022). In addition, through a metaphorical thinking approach, it can make the learning process of students meaningful because students can see the relationship between the concepts they learn and familiar concepts (Angraini et al., 2022; Çağırgan, Karaduman, & Sönmez, 2021). In the metaphorical thinking approach abstract concepts are metaphorized into real objects that exist in everyday life (Yetti & Afriyani, 2021). The characteristic of the metaphorical thinking approach is to bridge abstract concepts into more concrete things.

Learning steps using a metaphorical thinking approach are giving contextual problems, identifying key concepts, using metaphors to identify key concepts and drawing conclusions (Yetti & Afriyani, 2021). These learning steps will later be packaged in the form of worksheets that can direct students to be more independent in solving mathematical problems and encourage students to be able to solve practice problems according to the right procedures. So that later students will be more independent and have no difficulty in doing exercises both in class and at home.

Based on the results of observations and interviews and then the results of reviewing the opinions of previous relevant researchers, it is necessary to develop

varied teaching materials in the form of worksheet which can be effective teaching materials for students, as well as help students in solving mathematical problems because they are in accordance with mathematical procedures..

RESEARCH METHODS

The method used in this study is Research and Development. A series of processes or steps in order to develop a new product or perfect an existing product so that it can be accounted for (Sukmana, Supriatna, & Wardhani, 2022). In research and development of the metaphorical thinking approach-based worksheet, researchers use the ADDIE development model consisting of five steps in Figure 2, namely: 1) Analysis 2) Design 3) Development 4) Implementation 5) Evaluation (Setiadi, Yuliatmojo, & Nurhidayat, 2018).

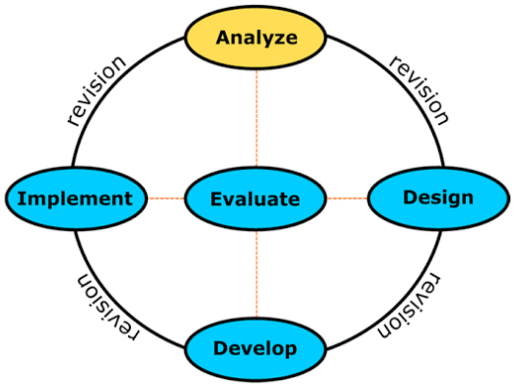


Figure 2. ADDIE Development Model Framework

The development procedure for the metaphorical thinking approach-based worksheet through a five-step ADDIE development model: 1) Analysis, namely Teacher Needs Analysis and Student Needs Analysis. 2) Design, namely Making Initial Drafts and Material Preparation. 3) Development, namely students' worksheet making and validity testing by Experts (material experts, media experts and linguists). 4) Implementation, i.e. Formative Evaluation (one-to-one evaluation, small group evaluation, field test) 5) Evaluation. This research was carried out in the even semester of the 2021/2022 academic year at MTs IT Bany Zuhud Wanasalam. The subject of the study was the 9th students in MTs IT learner Bany Zuhud, involving 31 learners. Then material experts, media experts and linguists involving Three Lecturers of Mathla'ul Anwar University Banten.

The types of data used in this study are in the form of qualitative and quantitative data, qualitative data in the form of criticism, suggestions and responses of experts and students while quantitative data consists of expert validation questionnaire sheets and student trial questionnaires. The data collection instrument used by researchers for the validation stage of experts used a closed questionnaire made using a rating scale while the student coa test questionnaire was made using a likert scale. The data analysis technique used in this development research is descriptive statistics, descriptive statistics is a way of analyzing data by describing or describing the data that has been collected sober without intending to make conclusions that apply to the public or generalizations. Assessments carried out by experts and students are processed with simple statistical data, namely using questionnaires with a grading scale range of 1 to 4. The score conditions used with the details in Table 1.

Table 1. Scoring and Its' Category

Score	Category
4	Excellent
3	Good
2	Not Good Enough
1	Very Bad

After the data were obtained from expert review activities and student trials, calculations were carried out to determine the quality of the metaphorical thinking approach-based worksheet for the procedural smoothness of students on the 9th grade in MTs IT Bany Zuhud Wanasalam. The trial calculation criteria for calculating the average score can be known using the following formula in Figure 3.

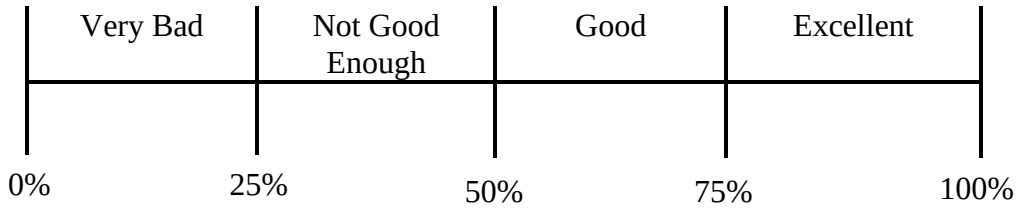


Figure 3. Criteria Score Range Line

The validity used for students' worksheet is based on metaphorical thinking based on the validity proposed by BSNP (Doyan, Susilawati, & Hardiyansyah, 2021). While the validity for the questionnaire sheet is the validity proposed by Arifin (2017). The students' worksheet products are said to be valid if students' worksheet products have

met the requirements with the level of material accuracy, media feasibility and language suitability in the excellent or good category. The indicator for validating by expert presented in Table 2.

Table 2. Specification for the Material Expert Validation

Aspects	Indicators	Grain
Eligibility of Contents	Material Coverage	4
	Accuracy of the Material	3
	Relevansi	4
Eligibility of Presentation	Completeness of Serving	3
	Presentation of Information	4
	Presentation of Learning	5
Based on a Metaphorical Thinking Approach	Contextual Problem Giving	1
	Identify Key Concepts	1
	Using Metaphors to Identify Key Concepts	1
	Conclusion	1
	Number of Grains	27

RESULTS AND DISCUSSION

One of the models of development research is the ADDIE development model. The ADDIE model consists of five steps, namely: 1) Analysis 2) Design 3) Development 4) Implementation 5) Evaluation. These five steps are a stage of development where the product will be developed into a better product. The following is an explanation of the stages in developing students' worksheet products based on a metaphorical thinking approach.

Analysis

There are two steps at the analysis stage carried out by the researcher, namely: needs analysis and curriculum analysis. At the needs analysis stage, researchers conducted observations and interviews with teachers of mathematics subjects and the 9^{th} students in MTs IT Bany Zuhud Wanasalam. Based on the observations made by researchers to the 9^{th} grade students in MTs IT Bany Zuhud Wanasalam, it can be seen that learning is still teacher-centered, students tend to be passive only listening and paying attention to the teacher's explanation. Only a few learners ask questions when given the opportunity to ask questions. Then students are asked to do practice questions related to the material presented, they find it difficult to do the practice questions and many of them are still

very confused to start the initial steps of doing the questions.

Then the results of the interview to the teacher stated that one of the factors for the ineffectiveness of learning in the classroom was the lack of teaching materials as a very important learning support. In learning, students only get material from the teacher's explanation and the teacher only conveys the material contained in the package book provided from the school with an amount that is not proportional to the number of students resulting in students experiencing difficulties in completing some tasks or exercises or lack of cognitive abilities possessed by students.

Then from the results of observations made at MTs IT Bany Zuhud, researchers got information that the curriculum used in MTs IT Bany Zuhud was a simplified 2013 curriculum. By conducting a curriculum analysis, it can be known the objectives that must be achieved by basic competence 3.7, namely Generalizing the surface area and volume of various curved side chambers (tubes, cones, and balls), and basic competence 4.7, namely Solving contextual problems related to surface area and volume of the curved side space (tubes, cones, and spheres) on the material of the curved side room.

The results of observations in the classroom, interviews and observations are used as material to develop students' worksheet products that are in accordance with the needs of students. The observation and interview situation presented in Figure 4. Based on the results of the needs analysis and curriculum analysis, the researcher seeks to develop metaphorical thinking approach-based worksheet for the procedural smoothness of students which can later hone the cognitive abilities of students, so that the learning process is more effective and more meaningful.

Figure 4. Observation and Interview Stages

Design

At this research stage, the researcher compiled a design to develop an students' worksheet product based on a metaphorical thinking approach to the 9th grade curved

side room building material. The design stages that have been carried out by the researcher are as follows: a) Planning learning objectives, learning activities, learning content and the assessment process. The material content in the students' worksheet developed by researchers is adjusted to the core competencies and basic competencies of mathematics for 9th grade in junior high school curriculum 2013 revised in 2020 material to build curved side rooms. Each activity contains a metaphorical thinking component. b) Researchers begin to design students' worksheet designs that are developed according to needs analysis and curriculum analysis. This students' worksheet is designed by paying attention to design principles in order to attract attention and motivate students. c) The compiler designs the product in accordance with the material and learning approach chosen by the researcher, namely build a curved side room using the metaphorical thinking approach. The designed students' worksheet consists of the students' worksheet cover, foreword, steps of the metaphorical thinking approach, procedural smoothness indicators, table of contents, basic competencies and achievement indicators, concept maps, worksheets, honing abilities, reference lists, author biodata, like in Figure 5.

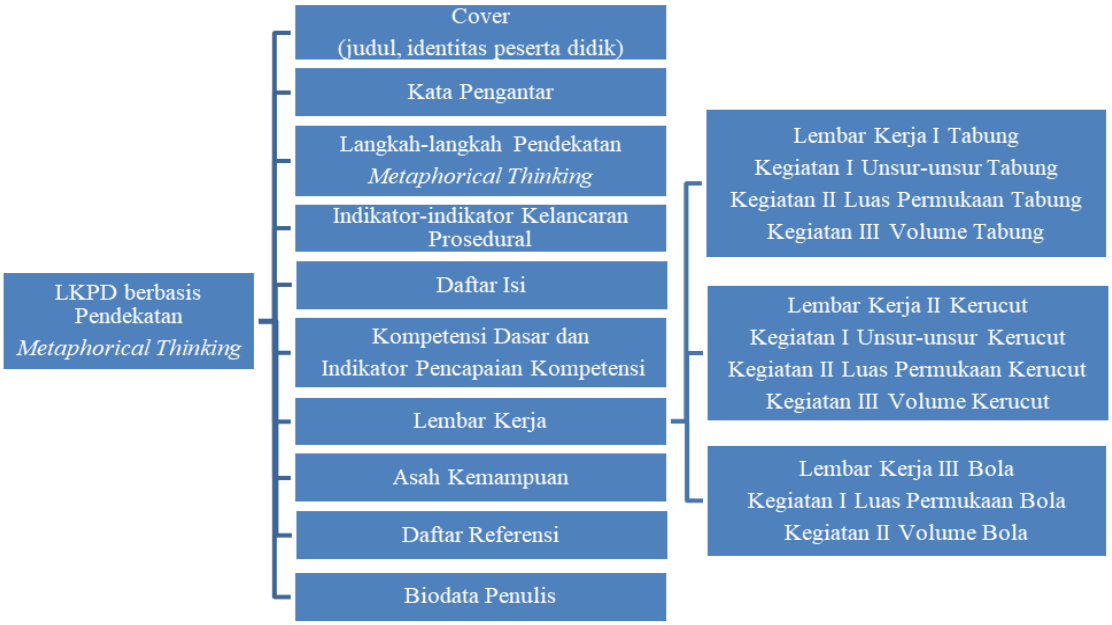
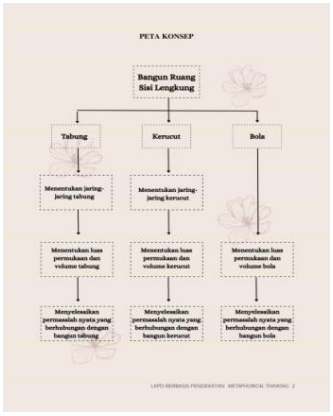


Figure 5. Worksheet chart

The designed product model like the students' worksheet cover (Figure 6a), table of contents (Figure 6b), and concept maps (Figure 6c) presented in Figure 6.

(a)

(b)



(c)

Figure 6. Worksheet draft

Development

At this stage, researchers carry out product development in two stages, namely the students' worksheet development process and expert testing. The students' worksheet product development process begins with the preparation of a draft to illustrate the students' worksheet cover illustration. Then the preparation of the manuscript of the students' worksheet content, determining the design in Canva and then the researcher ensures the device to be used to make the students' worksheet, giving the title to each students' worksheet activity, determining the color and typeface as well as the size of the writing for the cover and content of the students' worksheet, making design formats, editing students' worksheet activities and layouts, entering writing, drawings and materials to build curved side rooms in the students' worksheet design layout. Furthermore, the draft students' worksheet is submitted to the experts in the Expert Review test. The students' worksheet that has been developed is then validated by experts, namely material experts, media experts and linguists. This validation test is carried out to determine the feasibility of the metaphorical thinking approach-based worksheet and ask for advice or input related to the teaching materials developed. The following are the results of the expert recapitulation in Table 3.

Table 3. Expert Test Recapitulation Results

Expert	Result Score
Material Expert	79%
Media Expert	94%
Linguist	96%

Based on the results of the recapitulation of assessments from experts referring to the product feasibility category (material accuracy, media feasibility and language suitability), the students' worksheet based on the metaphorical thinking approach obtained the category of excellent (very valid). In this validation process, researchers get some suggestions or inputs on the product being developed. After making improvements on the advice of experts, in the next stage that students' worksheet (the model presented in Figure 7) is tested on students.

Figure 7. Final Worksheets

Implementation

Implementation is a real step to implement the learning system we are creating (Trisiana & others, 2019). After the product is revised and declared feasible, students' worksheet is tested on students. Researchers conducted a trial for the 9th grade students' in MTs IT Bany Zuhud Wanasalam to find out the responses of students and get input on the products developed by providing questionnaires. There are three stages of the students' worksheet trial for students, namely: one-to-one evaluation involving three students, small group evaluation involving 8 students and the field test involving 20 students. The following are the results of the recapitulation of the student trial in Table 4.

Table 4. Student Trial Recapitulation Results

Phase	Percentage
One-to-one Evaluation	90%
Small Group Evaluation	93%
Field Test	95%
Average Percentage	93%

The results of the trial assessment of the one-to-one evaluation stage, small group evaluation and field test (the assessment situation presented in Figure 8) in Table 4 obtained a percentage score of 93%. Based on the results of the percentage score, the

students' worksheet based on the metaphorical thinking approach can be categorized as very good (very valid).

Figure 8. One-to-one Evaluation, Small Group and Field Test

Evaluation

At each stage of development, students' worksheet products based on Metaphorical Thinking have an evaluation stage. Both in the design, development and implementation stages. The evaluation obtained is by including suggestions and comments from experts, namely material experts, media experts and linguists. Some recommendation for revision presented in Tabel 5. As well as conducting user trials for the 9th students in MTs IT Bany Zuhud Wanasalam with 3 stages of evaluation, namely one-to-one evaluation, small group evaluation and field test.

Table 5. Product Revision by Experts

Expert	Revision
Material	Addition of procedural smoothness indicators Addition of social aspects
Media	Replacement of illustrations on each activity Addition of answer sheets Addition of the sentence "procedural fluency ability" on the students' worksheet's cover Omission of ribbon illustrations on students' worksheet covers
Language	Replacement of the word "conclusion" to "conclusion"

The assessment results from experts obtained the results of the percentage of product feasibility with a material expert score of 79%, media experts by 94% and linguists by 96% and based on the percentage of these scores, the students' worksheet based on Metaphorical Thinking is categorized as very good.

The results of the user test of students go through three stages, namely the one-to-one stage, small group and field test by obtaining the results of the percentage of product feasibility with a one-to-one evaluation score of 90%, small group evaluation of

93% and field test of 95%, then the students' worksheet based on Metaphorical Thinking is categorized as very good.

Discussion

The efforts made by a teacher so that learning objectives are achieved can be seen in the Minister of Education and Culture No. 22 of 2016 concerning Standards for the Primary and Secondary Education Process, namely teachers are able to design effective learning (Sudana, 2018). Therefore, it is necessary to select learning media that are in accordance with the needs, in order to achieve learning objectives. The urgency of using learning media as a learning tool is to help educators convey messages and learning materials to students effectively and efficiently (Pratama & Saregar, 2019).

One form of visualization that can be done is through the students' worksheet. Students' worksheet is defined as printed teaching materials in the form of sheets of paper containing tasks, implementation instructions and steps for completing tasks on a certain material that must be done by students by referring to basic competencies and indicators that must be achieved (Jusmawati et al., 2021). Students' worksheet combined with metaphorical thinking approach, according to Hendriana (in Hasnarika, 2022) suggests that the metaphorical thinking approach is a bridge between model and interpretation, providing a great opportunity for students to exploit their knowledge in mathematics learning.

This research and development resulted in a product in the form of students' worksheet based on Metaphorical Thinking for the Procedural Smoothness Ability of Students to Build Curved Side Rooms for 3rd grade junior high school. This product is a learning resource designed using canva assisted by Microsoft Word 2012. Using the development model used in this study is the ADDIE development model (Barlenti, Hasan, & Mahidin, 2017). The ADDIE development model consists of five stages, namely analysis, design, development, implementation, and evaluation (Setiadi et al., 2018). These five steps are a stage of product development where the product will be refined or developed into a better product (Sukmana et al., 2022).

This development research was carried out based on the needs and curriculum analysis that researchers conducted at MTs IT Bany Zuhud Wanasalam. Based on the results of the study, it was found that there was a shortage of teaching materials in the

form of students' worksheet, and the available students' worksheet was not equipped with an attractive appearance. According to the results of interviews conducted by researchers to teachers of mathematics subjects and some students that learning seems monotonous, less effective and students are less active, thus affecting the cognitive abilities of students.

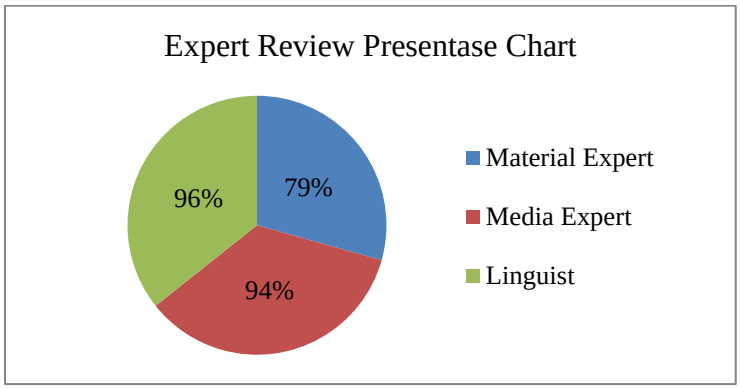


Figure 9. Expert Test Assessment Percentage Chart

Then this students' worksheet was designed by researcher and validated by three material experts, namely material experts, media experts and linguists. The validity used for the questionnaire question is the validity stated by Arifin (2017), namely the validity of the content and the validity of the face. Meanwhile, the validity used for students' worksheet is based on a metaphorical thinking approach based on the validity stated by BSNP (Doyan, Susilawati, & Hardiyansyah, 2021), namely content feasibility, presentation feasibility, language feasibility, and graphic feasibility. The following are the results of the recapitulation of the percentage of validation results and students' worksheet trials based on the metaphorical thinking approach for the smoothness of students in Figure 9.

Table 6. Average Percentage of Expert Review Assessment Results

Expert	Percentage
Material Expert	79%
Media Expert	94%
Linguist	96%
Average Percentage	90%

Based on the results of the average percentage of assessment conducted by the expert review in Table 6, it can be concluded that students' worksheet based on the metaphorical thinking approach for the procedural smoothness ability of students gets

very good criteria or can be said to be valid. In continum it can be seen as follows in Figure 10.

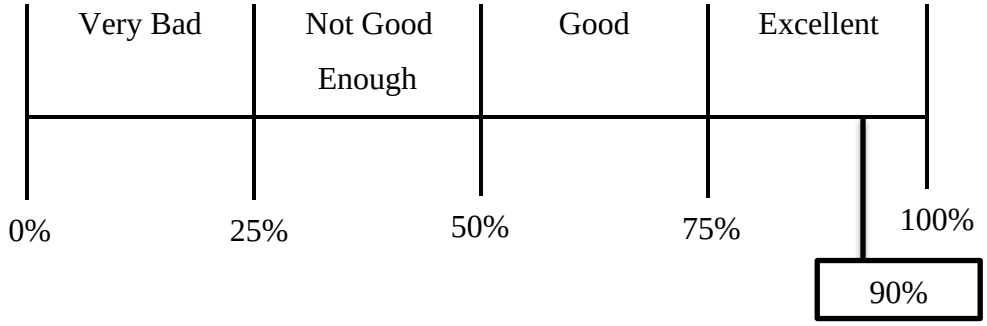


Figure 10. The average criterion line of expert test assessment

After the expert test stages, the next stage is implementation. Implementation is a real step to implement the learning system we are creating. Researchers implement MTs IT grade 3 student Bany Zuhud through three stages in Figure 11.

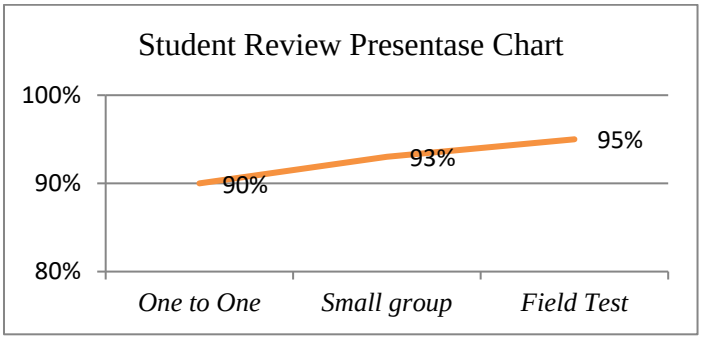


Figure 11. Learner Trial Assessment Percentage Chart

Based on the assessment chart in Figure 11, the trial of students' worksheet product users went through three stages, namely one-to-one evaluation, small group evaluation and field test. For the percentage score obtained has increased at every stage with an average percentage of 93% in Table 7, it can be interpreted that the students' worksheet product based on the metaphorical thinking approach has developed into a product that is suitable for use by students.

Table 7. Average Percentage of Student Trial Results

Phase	Percentage
One-to-one Evaluation	90%
Small Group Evaluation	93%
Field Test	95%
Average Percentage	93%

Based on the average percentage of the results of trials conducted by students in Table 7, it can be concluded that students' worksheet based on the metaphorical thinking approach gets very good criteria or can be said to be valid. In continuum it can be seen as follows in Figure 12.

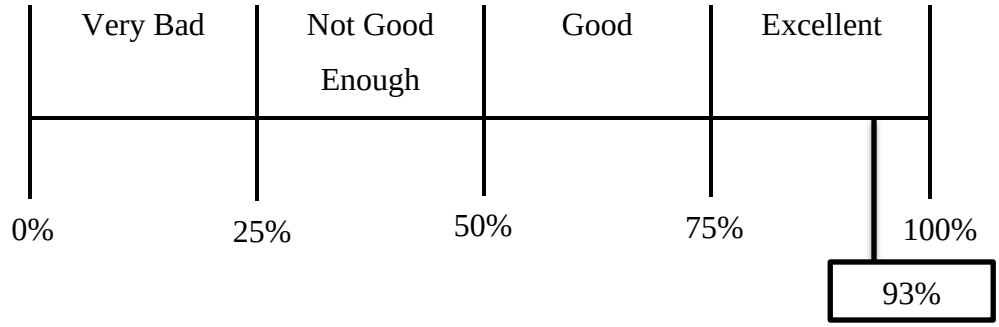


Figure 12. The average criterion line of student trial results

In the One-to-one evaluation stage, researchers are assisted by homeroom teachers to determine the students who conduct product trials. The homeroom teacher selected students with three categories according to the ability of the learners in Table 8. Sindi with high category, Roheni with medium category and Egi with Low category.

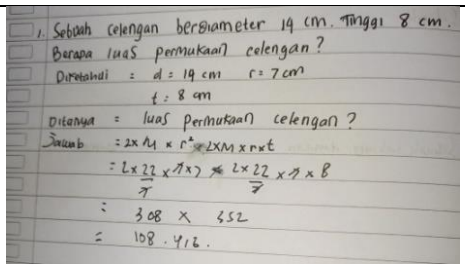
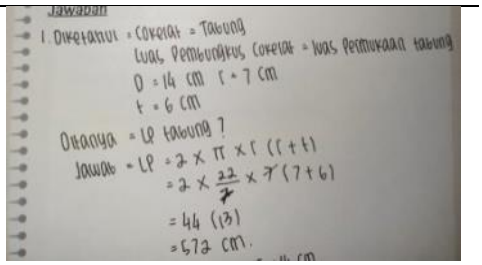
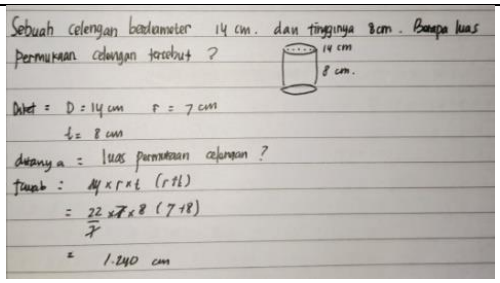
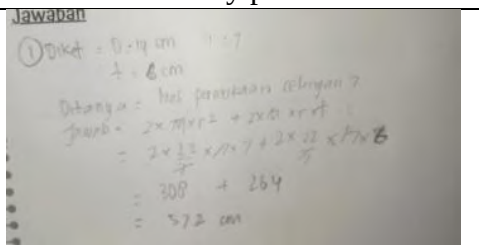
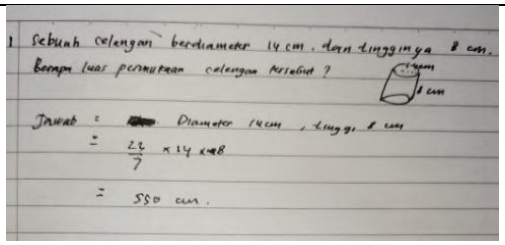
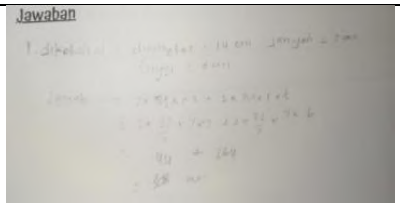
Table 8. Recapitulation of One-to-one Evaluation

Student Name	Number of Assessment Items	Maximum Score	Earned Score	Percentage Score
Sindi	9	36	33	92%
Roheni	9	36	32	89%
Egi	9	36	32	89%
Sum	27	108	97	276%
Overall Score Percentage				90%

Based on Table 8, it can be seen that the students' worksheet trial conducted by students with high, low, and medium categories got very good percentage score results. It can be interpreted that this students' worksheet can be said to be valid for use by students in the high, medium, and low ability categories. The metaphorical thinking approach-based worksheet makes students more active and more motivated in learning, and the steps presented in this students' worksheet help students in solving mathematical problems easily because they are adjusted to indicators of procedural fluency that is, it includes choosing the right procedures to solve mathematical

problems, using selected procedures, utilizing procedures, modifying or improving procedures (Firdaus, 2019). It can be seen from the work of students in Table 9.

Table 9. Student Work

Name	Before using students' worksheet	After using students' worksheet
Sindi (high category)	 - Able to Choose a Procedure Sufficiently - Able to Use the Procedure - Unable to Utilize the Procedure	 - Able to Choose Procedures - Able to Use procedures - Able to Utilize procedures - Able to Modify procedures
Roheni (medium category)	 - Unable to Choose a Procedure Yet - Unable to Use the Procedure	 - Able to Choose Procedures - Able to Use Procedures - Able to Utilize Procedures
Egi (low category)	 - Unable to Choose a Procedure Yet - Unable to Use the Procedure	 - Able to Choose a Procedure - Able to Use a Procedure - Unable to Utilize the Procedure

CONCLUSION

Based on the results of this development research, it was concluded that the metaphorical thinking approach-based worksheet for the procedural smoothness ability to the 9th students Curved Side Room Building Materials was declared very good or very valid. Based on validation tests by the material, media, and linguists experts with an average percentage of 90% and have been tested by users with stage one-to-one evaluation, small group evaluation and field test with an average percentage of 93%.

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DEVELOPMENT OF INTERACTIVE MATHEMATICS LEARNING MEDIA ON GEOMETRY MATERIAL

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Abstract

The purpose of this study was to describe the development of valid, practical, and effective learning media on Geometry materials with worksheets equipment. This research type was development research using the modified Borg & Gall procedures by several main steps, namely product analysis developed, initial product development, and product trials. The product trials carried out consisted of two stages, namely expert validation was carried out to know whether the created learning media was suitable for use or not, from the validation results it was concluded that learning media could be used with slight revisions, then small-scale trials were carried out to find out college student responses to learning media by using college student response questionnaires and conducting tests (evaluations) to obtain media effectiveness data, while the results of the development of interactive mathematics learning media are valid with scores of 3.64 and 3.36, practical with a score of 3.83 and very effective with 90% complete mastery of the material.

Keywords: Development, Geometry, Mathematics learning media.

Abstrak

Tujuan dari penelitian ini adalah untuk medeskripsikan pengembangan media pembelajaran materi Geometri yang valid, praktis dan efektif serta dilengkapi dengan lembar kerja. Jenis penelitian ini adalah penelitian pengembangan dengan prosedur Borg & Gall yang telah dimodifikasi dengan beberapa langkah utama yaitu analisis produk yang dikembangkan, mengembangkan produk awal, dan uji coba produk. Uji coba produk yang dilakukan terdiri dari dua tahap yaitu validasi ahli dilakukan untuk mengetahui apakah media pembelajaran yang dibuat sudah layak digunakan atau tidak, dari hasil validasi diperoleh kesimpulan bahwa media pembelajaran dapat digunakan dengan sedikit revisi, selanjutnya dilakukan uji coba skala kecil untuk mengetahui respon mahasiswa terhadap media pembelajaran dengan meggunakan angket respon mahasiswa serta melakukan tes (evaluasi) guna mendapatkan data keefektifan media, adapun hasil pengembangan media pembelajaran matematika interaktif ini adalah valid dengan perolehan skor 3,64 dan 3,36, praktis dengan perolehan skor 3,83 dan sangat efektif dengan 90% ketuntasan penguasan materi.

Kata kunci: *Geometri, Media pembelajaran matematika, Pengembangan.*

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INTRODUCTION

Mathematics was an important role in the development of science and also a universal science that underlies the development of modern technology, has an important role in various scientific disciplines, develops human thinking power, plays a role in the process of human life and as the language of science. In daily life, we cannot be separated from

mathematics, both from small things to sophisticated technological developments and the National Council of Teachers Mathematics (NCTM, 2000) stated that technology is essential in teaching and learning mathematics, it influences the mathematics that is taught and enhances college students' learning.

Since the role of mathematics is important, every college student should be interested and interested in learning mathematics. However, in reality college students' interest in learning mathematics is still low and the learning process is still less effective. Based on the results of observations on March 9, 2022 and March 16, 2022, class II semester college students of the Mathematics Education Study Program, Faculty of Science, Technology and Education, Universitas Tamansiswa, Padang, with the Field and Spatial Geometry course, it can be seen that college student learning interest is still low.

This is caused by several factors, one of which is the learning media used. Existing learning so far is still dominated by lecturers, while college students only come, sit, listen, take notes, and memorize, this situation has a bad impact on college students, one of which is that college students only master the material provided without knowing the benefits and how to apply knowledge or these lessons in daily life and college students become less active in learning.

To overcome this problem, researchers plan to design and develop an interactive mathematics learning media. Afriansyah and Arwadi (2021) stated that what can be done to increase college students' interest in learning is to use interesting learning media. According to Iswara, Darhim, and Juandi (2021) by using technology teachers are required to be creative and innovative in conducting learning and one of them is by changing methods, methods and media so that learning is no longer monotonous and conservative. The use of media in the learning process can generate new interests, desires and stimulate learning activities as well as bring positive influences on college students. In connection with these conditions, it can be said that college student learning motivation is something that is important to improve the desired learning outcomes (Rachmavita, 2020). In addition, this media can also be used by college students to study independently at home (independently) to repeat parts of material that they do not understand or to better understand the material that has been presented.

According to Kartini and Putra (2020), the current trend that is developing very rapidly is technology, so the development of learning media using this technology is quite

promising and according to Sakat et al. (2012), learning using technological media has a significant influence on learning. College students who are accustomed to using IT-based media indirectly develop their abilities in the field (Hendri & Anugrah, 2019). The developed interactive learning media can be used by college students for independent learning (Puspa, Hidayat, & Supriatno, 2021; Kamaruddin et al., 2021), and the interactive learning media developed allows college students to discover concepts independently (Has, 2021; Subekti & Prahmana, 2021), so that college students are actively involved in learning and college students feel challenged in finding (Simamora, 2020; Khusna et al., 2019).

Recognizing the many benefits of using technology and computer programs to develop interactive mathematics media as a tool in the learning process and the shortcomings of learning media in geometry material, the researchers tried to conduct research related to developing mathematics learning media in this case aimed at describing the media development process. interactive mathematics learning on geometry material and the results of its development.

RESEARCH METHODS

The model in this study refers to the procedural development model, which is a descriptive model and the development model used is the modified Borg and Gall (1989) model, which involves several main steps including 1) analysis of the product being developed, 2) developing the initial product, 3) product trials consisting of expert validations and revisions, small-scale field trials and product revisions, large-scale field trials and the final product.

This research was conducted at Universitas Tamansiswa, Padang. This research was conducted in the odd semester of the 2022/2023 academic year. The instruments used in this study were 1) Instructional media validation sheets filled in by design experts, multimedia, field of study, evaluation experts, and so on which are useful for reviewing the initial product. This validation sheet is given to the validator along with the learning media that will be validated to obtain input or data about the expert's assessment of the learning media. 2) College student assessment sheets for learning media, data collection with this sheet is useful for obtaining information about college student responses to interactive mathematics learning media. College students give a checklist (✓) in the

column provided for each question asked. The questionnaire was given to college students at the end of the learning activities carried out in class.

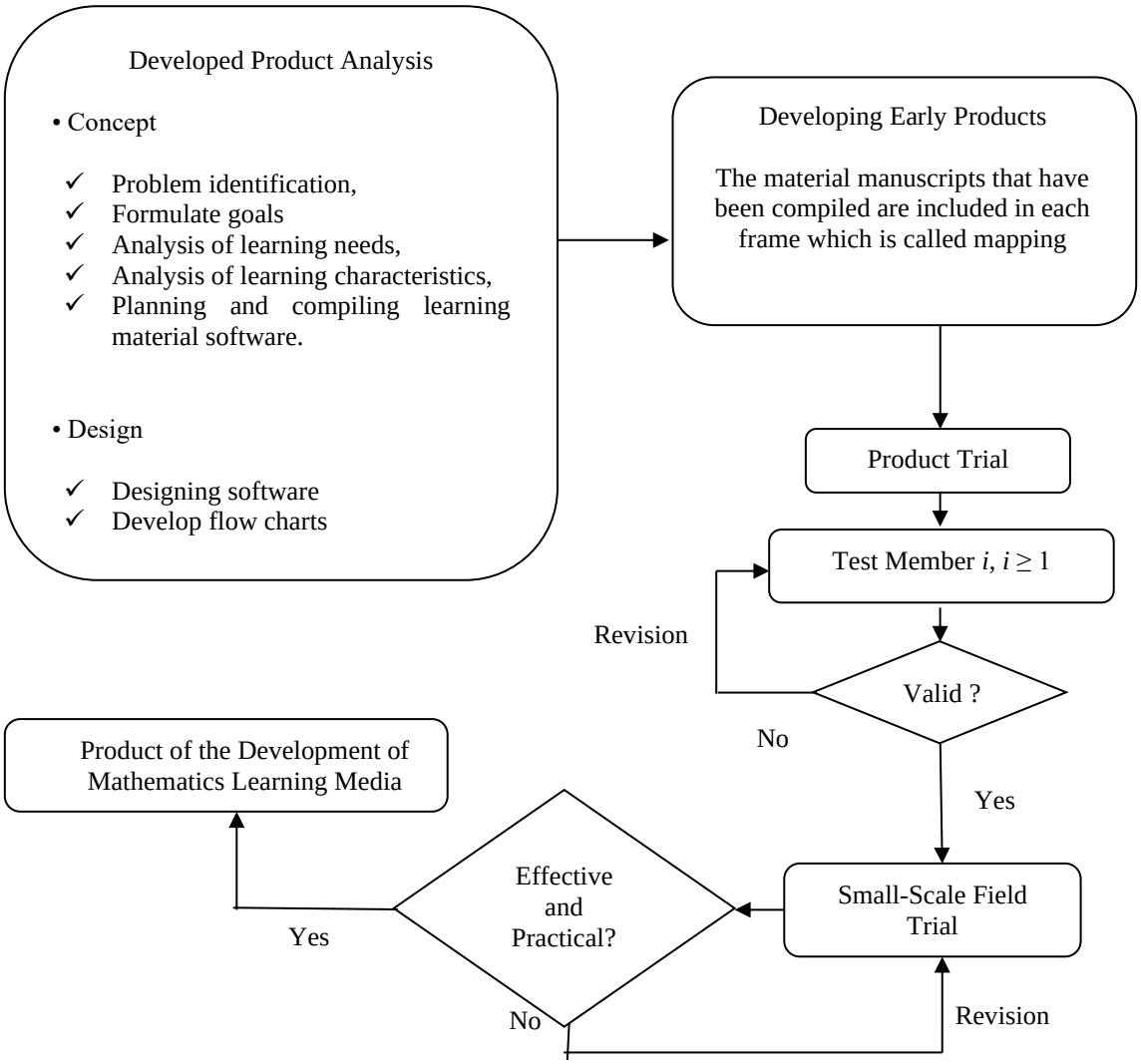


Figure 1. Research Implementation Procedure

Quantitative data validation results were analyzed using the average analysis technique based on the following steps: (a) determine the average of all validators for each indicator, (b) determine the validity score.

Table 1. Validity Criteria

Validity Score (V_a)	Validity Criteria	Description
$V_a = 4$	Very valid	No need for revision
$3{,}25 \leq V_a < 4$	Valid	No need for revision
$2{,}50 \leq V_a < 3{,}25$	Valid Enough	Partial revision
$1{,}75 \leq V_a < 2{,}50$	Less valid	Partial revision
$1 \leq V_a < 1{,}75$	Invalid	Total Revision

To test the validity of the media, the validity criteria are presented in the following Table 1.

Quantitative data from practicality trials were analyzed using the average analysis technique based on the following steps: (a) determine the average of all respondents for each indicator, and (b) determine practicality score. To test the practicality level of the media, the criteria for the practicality level are presented in Table 2.

Table 2. Practicality Criteria

Practicality Score (P)	Practicality Criteria	Description
$P = 4$	Very practical	No need for revision
$3{,}25 \leq P < 4$	Practical	No need for revision
$2{,}50 \leq P < 3{,}25$	Practical enough	Partial revision
$1{,}75 \leq P < 2{,}50$	Less practical	Partial revision
$1 \leq P < 1{,}75$	Not practical	Total Revision

Quantitative data from the results of the effectiveness trials were analyzed using the average analysis technique based on the following steps: (a) data on the results of the material mastery test (evaluation), that is: 1) determine the average value of the test subjects for each question, and 2) determine the value of effectiveness, and (b) determine the percentage value (%).

To test the level of effectiveness of the media, the criteria for the level of effectiveness are presented in Table 3.

Table 3. Effectiveness Criteria

Percentage of Value (%)	Level of Effectiveness	Description
$85 \leq E < 100$	Very effective	No need for revision
$70 \leq E < 85$	Effective	No need for revision
$55 \leq E < 70$	Effective Enough	No need for revision
$50 \leq E < 55$	Less effective	Revision
$0 \leq E < 50$	Not effective	Revision

RESULTS AND DISCUSSION

Expert test or validation is carried out with the help of two validators, namely the mathematics lecturer and the teacher. Each validator provides assessments, corrections, comments and suggestions on learning media and research instruments. From the results of this validation the researcher can determine whether the learning media and research

instruments still need to be revised before small-scale field trials or are ready to be tested in the field.

Analysis of the developed product

At this stage an analysis of the various things needed in product development is carried out, both in designing learning devices and in making learning devices.

Analysis of the needs required in the design of learning devices

The three to develop a product is concept, design, and collecting materials. At the stage to develop the concept, an analysis of the needs needed in the design of learning devices is carried out, starting with studying the material to be made. This is done by selecting material in the curriculum and also the results of observations that have been made. Based on the existing problems, geometry material was chosen with the sub-topic of distance in geometric shapes to be developed in interactive mathematics learning media.

Product design is carried out in two stages, in the first stage the general structure of the software to be developed is carried out, in this case in the form of a tutorial (presentation of subject matter in stages). The general structural form presented in the device is like the scheme in Figure 2.

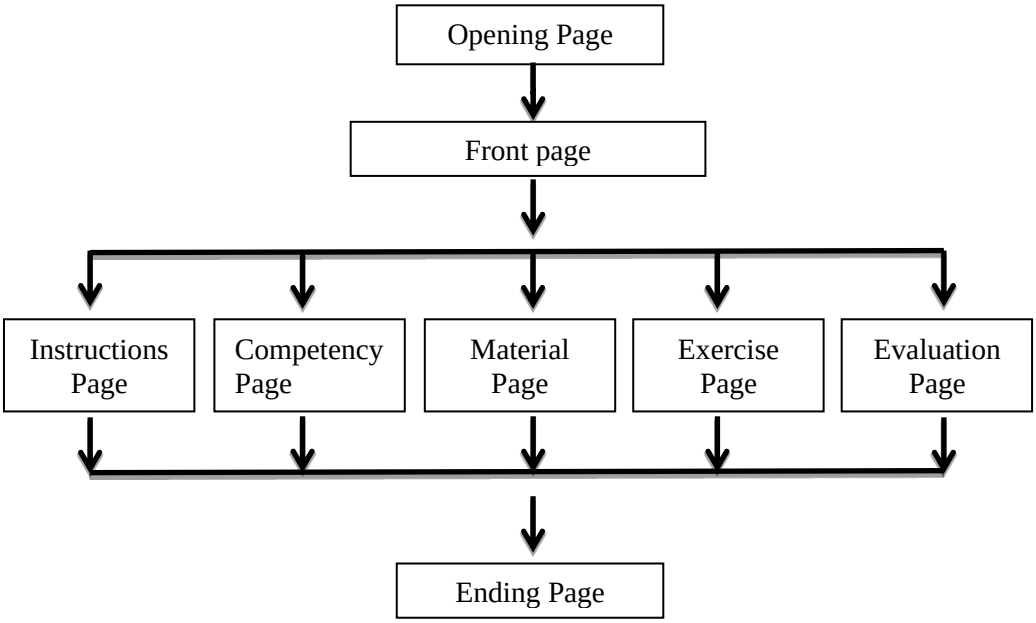


Figure 2. General Structure of Media

At this stage, the materials needed to make the product are collected, such as the main material that will be made, namely material about geometry, besides collecting the

basic material, other aspects needed in making the product are also collected, such as video, audio and images related to the product being made.

Analysis of the needs required in making mathematics learning media

In addition, a need-analysis of the requirements design in terms of materials, it is also necessary to analyze the needs for the manufacture of products in the form of software and hardware. The hardware used in the development of learning media is in the form of a laptop unit and the software used in making mathematics learning media is Macromedia Flash MX 8, 3D Animation, and Microsoft Office Word 2019.

Developing the initial product

The next process after analyzing the product to be developed is developing the initial product, at this stage the material that has been prepared is included in each frame in the Macromedia Flash MX 8 software. After developing the product Initial editing process is carried out on the product being developed.

Trials of the product

After the initial product was finished, a product trial was carried out which consisted of two stages, namely expert testing and small-scale field trials.

Media Expert Validation Results

The results of the validator's assessment of the developed media have been recapitulated in Table 4.

Table 4. Media validation results and recapitulation

Aspects Assessed	I_i
Instructions for using learning media are clear.	4
Media can be operated easily.	4
The text on learning media is easy to read.	3
The display of images on learning media is of high quality.	4
The use of animated images is already interesting	3
Color composition is good.	4
The typeface used is consistent.	4
The font size used is good.	3
The program display on each page is good.	4
The language used is according to the ability of students.	4
Sound on learning media is good.	3
Validity Score (V_a)	3,64

I_i is the Average score of each aspect

Based on the results of media expert validation, the validity score (V_a) was 3.64. According to the established validity criteria, the learning media can be said to be valid. This score indicates that the media is feasible to be tested and carried out several product revisions.

Learning Expert Validation Results

The results of the validator's assessment of the material in the developed media have been recapitulated in Table 5.

Table 5. Results and recapitulation of material validation on media

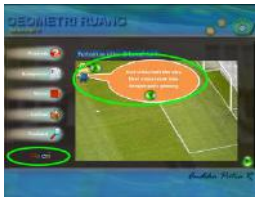
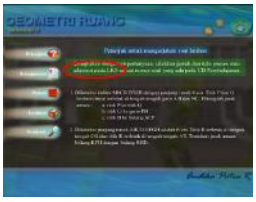
Aspects Assessed	Validator 1	Validator 2	I_i
Quality of content and purpose			
a) The material is in accordance with competency standards, basic competencies, and learning objectives.	4	4	4
b) Learning media according to the concept.	3	4	3.5
c) Animation and pictures according to the material.	3	3	3
d) Examples of questions and exercises according to the material.	3	4	3.5
e) Sample questions are arranged from easy to difficult.	3	3	3
f) The media can increase students' learning motivation on distance material in geometric shapes.	4	3	3.5
Technical quality			
a) The simulation presented in this media can help students understand the concept of distance.	4	4	4
b) Sentences on learning media are clear.	4	3	3.5
c) The placement of the buttons in the media does not confuse students.	3	3	3
Quality of learning			
a) Media can facilitate understanding of distance material in geometric shapes.	3	3	3
b) Media can provide opportunities to learn according to ability.	3	4	3.5
c) The media has facilitated students' independent learning.	3	3	3
d) Media can involve students actively.	4	3	3.5
e) Media can construct students' understanding.	3	3	3
Validity Score (V_a)			3.36

Based on the results of the validation of learning experts, the validity score (V_a) was 3.36. According to the established validity criteria, the learning media can be said to be valid. This score indicates that the media is feasible to be tested.

According to Nieveen and Folmer (2013) media includes content validity (relevance) and consistency validity (consistency). A product is said to be valid if the formulation and

preparation of the developed media product are based on scientific knowledge and are designed logically, and there is a relationship between the components in the developed media product. From the explanation above, interactive mathematics learning media on geometry material can be said to be valid. The media revision process before the media is developed is said to be valid as follows.

Table 6. Revision

Before Revision	After Revision	Before Revision	After Revision
			
Before Revision	After Revision	Before Revision	After Revision
			
Before Revision	After Revision	Before Revision	After Revision
			
Before Revision	After Revision		
			

After making improvements to the validation results of media experts as well as material experts, this interactive mathematics learning media was tested in small groups. This trial was conducted in three meetings for learning and one meeting for a material mastery test (evaluation) and students filled out student assessment sheets for interactive mathematics learning media. The trial implementation schedule was carried out 4 times in April and May.

Based on the practicality criteria that have been determined by the researcher,

learning media is said to be practical if the practicality score data at least 3.25. The results of observing the implementation of learning media are presented in Table 7.

Table 7. Observations on the effectiveness of learning media

Aspects Assessed	I_i
Media can be operated easily.	4
The use of learning media by students according to the time allocation.	4
The implementation instructions in the learning media have been carried out by students.	4
The material in the learning media has been understood by students.	3
The evaluation questions are in accordance with the material.	4
The use of this learning media can be used as a learning resource.	4
Practicality Score (*P*)	3,83

Based on the results of observations of the implementation of learning media, the practicality score (*P*) was 3.83. According to the established practicality criteria, learning media can be said to be practical and do not need to be revised. According to Nieveen and Folmer (2013) a product is said to be practical if the developed media can be used in real situations where the media is created and developed. Internally the developed media can be applied in class and operationally the developed media can be applied properly by the teacher. From the explanation above, the developed media can be said to be practical.

One of the criteria for the effectiveness of learning media is the completeness of learning outcomes and the recapitulation of the results of the material mastery test (evaluation) for all college students is presented in Table 8.

Table 8. Material Mastery Test Recapitulation (Evaluation)

Name	Score	Description
FSM	100	Achieved
RDA	65	Not Achieved
AK	90	Achieved
FKM	80	Achieved
NP	75	Achieved
TKT	75	Achieved
MJK	75	Achieved
MFC	80	Achieved
ZA	80	Achieved
I	90	Achieved
Completeness Percentage	90%	Very effective

Based on Table 8, the percentage of completeness in mastering the material is 90%, but there is still one college student who has not mastered and understood the material in interactive media learning media. According to the established effectiveness criteria, learning media can be said to be very effective and do not need to be revised.

A product resulting from the development is said to be effective if it can achieve the expected learning objectives. Media as a development product is said to be effective if students' activities in participating in the learning process use development products with a high category (Nieveen & Folmer, 2013). From the explanation above, the media researchers have developed can be said to be effective.

CONCLUSION

Based on the research results obtained, it can be concluded that the results of developing interactive learning media on the resulting geometry material are valid with scores of 3.64 and 3.36, practical with scores of 3.83 and very effective with 90% mastery of the material. Suggestions for this interactive mathematics learning media are that evaluation questions are still in the form of objective questions and questions need to be developed in the form of descriptions and field trials only up to small-scale tests, namely one class only and further research needs to be continued for large-scale trials.

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THE DEVELOPMENT OF STUDENT WORKSHEET BASED ON PROBLEM BASED LEARNING APPROACH ON MATRICES TOPICS

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Abstract

This study aims to develop Problem Based Learning (PBL)-based worksheets to improve student's critical thinking skills in contextual problem solving. The research design used is a feasibility analysis by research and development methods. The research was carried out using research and development (R&D) research and development methods. The sample consisted of 40 students from science programs in 11th grade. The data collection instrument used is the expert assessment sheet, student responses to the created worksheet. The development procedure with 8 stages namely potentials and problems, information gathering, product design, expert validation, first revision, product trial, second revision, final product. From the results obtained the average feasibility value by the media is 81.46% (very feasible), the average graphic feasibility value is 81.85% included in the very feasible criteria, the language eligibility average value is 76% included in the appropriate criteria and the average value of student responses is (87.40%) (very positive).

Keywords: Matrices, Problem based learning, Research and development, Student worksheet.

Abstrak

Penelitian ini bertujuan mengembangkan lembar kerja berbasis PBL untuk meningkatkan keterampilan berpikir kritis siswa dalam sebuah pemecahan masalah secara kontekstual. Dengan rancangan penelitian yang digunakan adalah analisis kelayakan dengan metode penelitian dan pengengembangan. Sampel terdiri dari 40 orang siswa dari program sains di kelas XI. Instruman pengumpulan data yang digunakan adalah lembar penilaian Ahli, respon siswa terhadapat lembar kerja yang dibuat. Prosedur pengembangan dengan 8 tahapan yaitu potensi dan masalah, pengumpulan informasi, desain produk, validasi ahli, revisi pertama, uji coba produk, revisi kedua, produk akhir. Dari hasil yang diperoleh nilai rata kelayakan oleh para media yaitu 81,46% (sangat layak), nilai rata kelayakan kegrafika yaitu 81,85 % termaksuk dalam kriteria sangat layak, nilai rerata kelayakan Bahasa yaitu 76 % termasuk dalam kriteria layak serta nilai rerata respon siswa yaitu (87,40%) (sangat positif).

Kata kunci: *Lembar kerja siswa, Matriks, Pembelajaran berbasis masalah, Penelitian pengembangan.*

How to Cite: Aneliana, A., Ditasona, C., & Manalu, R. U. (2022). The Development of Student Worksheet Based on Problem Based Learning Approach on Matrices Topics. *Brillo Journal, 2*(1), 54-62.

INTRODUCTION

Education in Indonesia is now implementing the 2013 curriculum design which is expected to give birth to useful, imaginative, creative individuals through coordinated mental, ability and information strengthening (Eriyani et al., 2022). SMA 51 Jakarta is one of the schools that applies the 2013 curriculum which is adjusted to the achievement of the competencies set in the 2013 curriculum which emphasizes. Students can

understand material with contextual problems and solve problems independently or in groups actively, creatively and innovatively. One of them is learning which includes many aspects of real life, namely mathematics which contains a realistic context, by presenting mathematical material in problems in daily life (Sari & Ditasona, 2019; Glasnovic-Gracin, 2018; Maryani & Widjajanti, 2020).

Through the Problem Based Learning approach in the 2013 curriculum the competencies expected for educators and students in terms of skills, attitudes and knowledge can be achieved optimally by solving mathematical problems using the Problem Based Learning approach so schools can apply the PBL learning model in the form of teaching materials in the form of (tools, materials, texts, and others) as learning resources or additional references for educators and students, for example student worksheets (Ramury, Gustina, & Putri, 2020).

Based on the researcher's experience when completing field experience practice at school, it was found that the material displayed during the lesson was not the result of the teacher's own design, not even all students had the teaching material. Where students only work on competency test questions and learning is still based on lectures. During the PPL implementation, the researcher saw that the teaching materials owned by the students did not provide enough stimulus so that student learning activities became passive. through the dissemination of written interviews, it appears that the school requires the development of learning media for the learning process where the learning process still uses lecture techniques and in the learning process at the school uses a scientific approach and students are seen to be less active in asking questions. While what is expected in class learning is active students in asking questions and students can develop themselves in thinking and solving a problem contextually, with the development of teaching materials students can study independently or in groups to increase activity and creativity (Kristin, Ditasona, & Lumbantoruan, 2021). By learning to use worksheets due to a lack of students' understanding of the material and teaching materials, therefore it is necessary to develop problem-solving-based teaching materials such as the Problem Based Learning approach to find out whether student learning outcomes increase or decrease when students are emphasized to look for problem concepts first.

The use of student worksheets can help teachers in learning activities by discovering new concepts through the creativity of the students themselves (Ramury et al., 2020). In

the student worksheet, students will get material, summaries, and assignments related to the material that will be obtained in the lesson (Yulianti, Rusilowati, & Nugroho, 2020; Wahyuni, Efuansyah, & Sukasno, 2020).

Learning mathematics at SMA Negeri 51 Jakarta needs to be taught using the PBL approach to foster self-ability creatively, innovatively and critically which can develop character and improve students' cognitive learning outcomes. Matrix material is one of the mathematics materials that is contextual and closely related to everyday life which is learned in the 11^{th} grade. Matrix material in general is often encountered on problems related to the economy, in the calculation of expenses. The interrelationship of matrix material and everyday life is very much tied to various approaches that help to facilitate learning. Efforts to overcome the observations found such as the unavailability of PBL-based teaching materials and students' lack of understanding of problems based on everyday problems. Based on this description, the development of student worksheets based on the PBL approach on this matrix material would be able to answer the problems that researchers found at SMA Negeri 51 Jakarta.

RESEARCH METHODS

The sample in this study were high school students in the 11^{th} grade on science program. 40 students were involved in this research. 20 students were the first group of 11^{th} grade on science program and another 20 students were the second group of the 11^{th} grade on science program. The type of research used was research and development (R&D) method with the fourth level to produce a certain product, then testing the feasibility of a product would be carried out. The stages in the implementation of the research were carried out based on the Borg and Gall model with 8 stages of development namely potentials and problems, information gathering, product design, expert validation, first revision, product trial, second revision, final product (Nugroho et al., 2017).

The instruments in this study were interview guides for conducting needs analysis, validation sheets, and student questionnaires. Expert validation was carried out by 5 people each including 2 material experts, 2 learning media experts and 1 language expert. The validation sheet uses a Likert scale with a score of 1 to 5.

Then the result data from expert validators collected were analyzed using quantitative descriptive analysis techniques in the form of scores and percentages for

categories with a predetermined rating scale. Furthermore, after presenting it in percentage form, the next step is to describe each indicator. To find out the feasibility of developing an PBL approach-based worksheet, according to Arikunto (2013), it is assessed with the highest scale "very feasible" and the lowest scale "not feasible" with reference to the assessment criteria and categories in Table 1.

Table 1. Criteria for Validation Score Results

Percentage	Eligibility category
81-100%	Very feasible
61-80%	Decent
41-60%	Pretty decent
21-40%	Less feasible
0-20%	Not feasible

Student questionnaires are used to determine student responses to the products used. This questionnaire consists of 17 questions with four indicators, including interest, material, PBL components, and language as shown in Table 2.

Table 2. Criteria and Indicators of Student Response Questionnaires

Criteria	Indicators	Item Number	Total
Student Response	Interest	1-4	4
	Content	5-11	7
	PBL learning components	12-15	4
	Language	16-17	2

The percentage of student response questionnaire results will then be classified based on categories in Table 3.

Table 3. Percentage of Student Response Questionnaire Criteria

Percentage	Eligibility category
81-100%	Very positive
61-80%	Positive
41-60%	Less positive
21-40%	Not positive
0-20%	Very Not positive

RESULTS AND DISCUSSION

Needs analysis is the first step to find out the formulation in the development of PBL-based worksheets through observations with the SMA Negeri 51 Jakarta school which

was conducted on April 12, 2022. The observations made included teaching materials, media, and the physical condition of the school, students and teachers. Analysis of the availability of teacher and student learning media shows that they have used mathematics textbooks as a medium carried out in learning.

The results of written interviews with teachers in mathematics at SMA Negeri 51 Jakarta during mathematics lessons showed that they did not use student worksheets but only used textbooks and listened to explanations directly from the teacher. The results of the interviews also show that teachers really need teaching materials such as PBL-based worksheet. The use of PBL-based worksheet is intended to facilitate students in learning. In worksheet, it is possible to present contextual problems closely related to students' daily life.

After obtaining data about user needs, the researcher collects information related to learning materials. At this stage the researcher collects the core competencies and basic competencies contained in the curriculum used at the school.

The design process is carried out by compiling an outline format that includes material, topics, descriptions and general goals explained in PBL-based worksheets. More specifically, the design carried out by the researcher includes student worksheet covers, prefaces, table of contents, instructions for using student worksheets, core competencies, basic competencies and achievement indicators, concept maps, learning activities, learning objectives, material descriptions, exercises, summaries and bibliography. The suitability of the material is very important in the preparation of worksheets to describe the content to be compiled. After the design is obtained, the researcher continues the research process to the validation stage.

The results of the validation carried out by 2 material experts are in the range of the appropriate and very feasible categories as shown in Figure 1.

From the results of material validation, the linguistic aspect obtained the highest percentage score of 83.77% in the very feasible category. After that, it was followed by the content feasibility aspect with a percentage of 81.46%. The presentation aspect has the lowest percentage, namely 79.16% but is still in the proper category. Of the three percentages obtained an average percentage of 81.46% with a very feasible category. Thus the design of the student worksheet is declared valid and very feasible to use.

In addition to material validation, validation is also carried out related to learning

media. In this validation the aspects assessed include content design, cover design, layout, appearance and size. The validation results from 2 media experts obtained an average percentage of 81.85% with a very feasible category. The validation results from language experts obtained the lowest score of 76%. This score is still in the decent category.

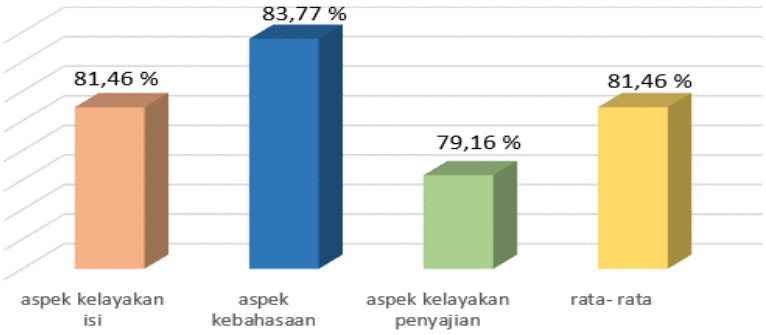


Figure 1. Content Expert Validation Percentage

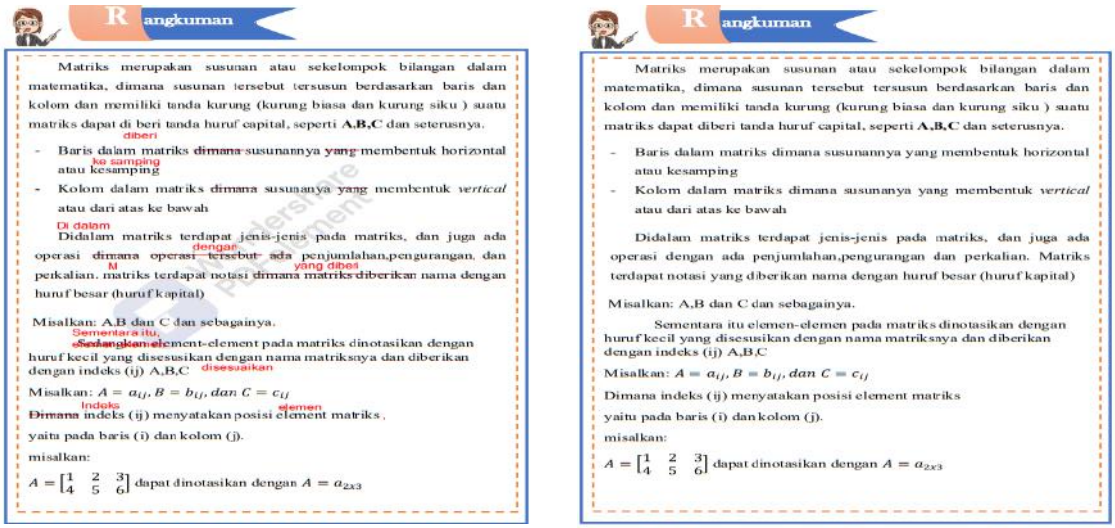
Even though it has been declared valid and feasible to use, researchers need to make improvements based on suggestions from validators. Some of the improvements made include the cover design, preface, writing a table of contents, core competencies and basic competencies, concept maps, improvements to the content of the subject matter, improvements to the sentence questions, and writing references.

Tabel 4. Suggestions and Improvements from Media and Language Experts

Suggestions before stage 1 revision	Improvements after stage 1 revision
There are some texts that already have large fonts, then are bolded so that they become unclear. Some titles and subtitles do not start with a capital letter and it is better to use a formal typeface	Fonts and titles have been adapted to suggestions with size 12 and fonts have been adjusted to sizes 12, 14 and more formal fonts
The color combination is more attention. The red color on the cover that says "mathematics" is too bright, it's best to lower the color tone so it looks a bit softer. Color selection also affects the reader's interest, choose soft or weak colors so that it creates comfort when reading worksheet.	The color has been adjusted according to the validator's suggestion with a smaller size and softer color
The use of the word "where" is not standard for conjunctions	Has been corrected according to the validator's suggestion
Some sentences are too long for maximum readability.	It has been corrected with sentences that are simpler and easier to understand.

Suggestions for improvement from language and media experts include writing using capital letters, standard words, and using colors in writing that are too flashy can interfere with user comfort when reading. The validator also suggests simplifying sentences that are too long to make them easier to understand. Some examples of suggestions for improvement from language experts are shown in Table 4.

In addition to providing suggestions on the validation sheet, the validators also provide direct comments on the student worksheet documents. This really helps researchers to find out in detail the parts that must be corrected on student worksheets. As seen in Figure 2, the validator provides many comments in terms of the procedure for writing sentences, as well as choosing words.



(a) (b)

Figure 2. Validator Comments on Student Worksheets (a) and their Improvements (b)

Limited class trials were carried out using worksheets based on the PBL approach to 40 students in the first and second group of the 11th grade on science program at SMAN 51 Jakarta. In this limited class trial each class was taken by 20 students as respondents. Based on the results of limited trials, student responses to the worksheet that were developed were very positive. This can be seen from the interest aspect obtained from the limited test getting a percentage (85.71%) with a very positive category, material/content aspects getting a percentage (87.59% in a very positive category, aspects of PBL learning components getting a percentage (86.855) with a very positive category, in the discussion aspect it gets a percentage (89.39) with a very positive category and the average obtained from student responses is a percentage (87.39) with a very positive category. Thus the

developed worksheet is interesting, the material easy to understand, language that is easy to understand and worksheet in accordance with the PBL approach.

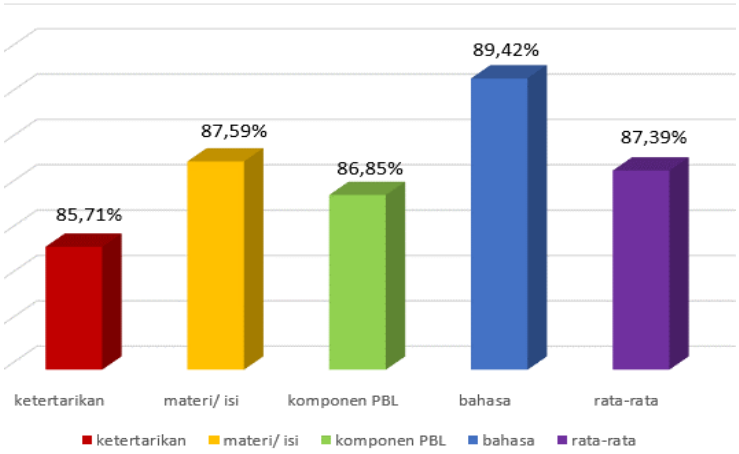


Figure 3. Percentage of Student Responses to Worksheets

CONCLUSION

PBL-based worksheet to matrix material for 11th grade students obtained an average percentage score for the feasibility aspect of content experts by 81.46%, the feasibility aspect for media graphics by 81.85%, and the language feasibility aspect by 76%. Thus, the student worksheet product is valid and feasible to use.

Student responses to the developed worksheets products in limited trials, from the aspect of interest obtained from limited trials, got a percentage (85.71%) in a very positive category. Material/content aspects get a percentage (87.59% in a very positive category. Aspects of the PBL learning component get a percentage (86.855) in a very positive category. On the language aspect get a percentage (89.39) with a very positive category. The average obtained from the students' responses, a percentage (87.39) was obtained with a very positive category. It can be concluded that the developed worksheet received a very positive response from students as its users.

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