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Mathematics Mobile Blended Learning Development: Student-Oriented High Order Thinking Skill Learning

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Abstract: This study aims to develop a mathematics learning application, namely Android-based mobile learning to increase students' High Order Thinking Skills (HOTs). The result of mathematics learning media is a valid and practical mobile learning application product. "Mastering Math" is the name of a mathematics e-learning application designed as a mobile or smartphone application, with specifications for the OS Android. The procedure for the development of virtual mathematical media used the development of the 4D model of Thiagarajan: (1) define; (2) design; (3) develop, and (4) disseminate. The trials conducted included five expert judgments and a small group. The research instruments used were a validation sheet, a practical assessment sheet by the teacher, a practical assessment sheet by students, and a media effectiveness test instrument. Data analysis was performed using Cochran's Q test for similarity of expert validation and qualitative analysis. The teaching materials used are junior high school teaching materials with validity and practicality in the good category to increase students' HOTs. This research implies that the learning of mathematics is more effective and efficient, students' divergent thinking develops, and their learning motivation for mathematics increases.

Keywords: *E-learning, R & D, smartphone application, Thiagarajan model.*

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Introduction

Dependency and rapid technological innovation cannot be avoided. Schools and universities can utilize technology such as (1) internet connection and connectivity at all times; (2) using projectors and visuals; (3) digital trace in education; (4) online degree through the utilization of technology (Raja & Nagasubramani, 2018). Jihad et al. (2018) reported that the study of mathematics by mobile phone using the android application is suitable to be applied in mathematics because it has functions that include: (1) mobile learning as a learning supplement, as a source of practice for doing questions or understanding related material; (2) mobile learning as a compliment, to complement the material in class; with mobile learning, students can do exercises and as an improvement whenever they have difficulties in learning; (3) mobile learning can be used as a substitute for module books. Regarding technology, Ashim et al. (2019) state that the use of mobile learning needs to be applied to create fun learning. To create interactive learning, teachers need to innovate by following current technology developments. Based on one of these principles, it cannot be denied that the role of technology in learning is essential.

Implementation of e-learning in several Malaysian universities such as the Faculty of Education of the University Kebangsaan Malaysia (UKM) in the learning process has been good, the e-learning facilities used in these institutions are adequate. The majority of the lecturer use several mathematical softwares such as Geogebra, Cabry, Maple, and other softwares in learning. According to Maat and Zakaria (2011) and Azizul and Din (2018) the use of multiple media e-learning of highly varied, including Kahoot, Canva, Youtube, Quizziz, Whatsapp, Telegram, and Google Classroom, which are very interesting for students. Besides, the attitude of students using e-learning in teaching was positive, in the sense that they were happy to learn, active in class, feeling comfortable, and responding well when the learning took place. Likewise, the implementation of e-learning at Aminuddin Baki's Malaysian National School (SMK) went well. The applications used by teachers are WhatsApp, Telegram, and MS Office 365. The teachers and students also used the

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teaching and learning platform Digital Educational Learning Initiative Malaysia (DELIMa) that was introduced by Malaysian Ministry of Education to maximize e-learning especially during the spread of Coronavirus disease (COVID-19) pandemic. Google Classroom, Google Meet, Google Form are used daily in teaching and learning by creating classes, distributing assignments, quizzes, tests, and also communicating with the students.

Setyadi (2017) states that the development of Android-based mobile learning can motivate students to practice working on mathematical problems. In accordance to this opinion, the results of Nuryadi's (2019) research show that Android-based mobile learning is also very influential on High Order Thinking Skills (HOTs) because the development of Android-based learning media can significantly impact on increasing the ability to understand and solve mathematical problems. Thus, technology can be said as one of the keys to success in mathematics, especially in high-level mathematical thinking skills.

The HOTs of students who have learned through blended learning is far better than the others with learning and e-learning full conventional approach (Yaniawati, 2013). Politze et al. (2017) say that mobile learning is the solution for expanding and enriching the learning environment. The research by Politze et al. (2017) shows that learning with mobile learning needs to blend with other learning environments, such as books, papers, classrooms, laptops, and tablets as a few of the requirements in facing new challenges for a higher level. This is also emphasized by Suartama et al. (2019), that most students prefer to access information via their smartphone rather than using a laptop or Personal Computer (PC). Therefore, learning using mobile blended learning can improve higher-order mathematical thinking skills. This is important for further research on the effectiveness of implementing mobile blended learning-based learning. Accordingly, they need their mobile learning media to improve their HOTS. Mobile learning also raises interest among students to a greater extent to engaging themselves in co-academic activities such as innovation and in Science, Technology, Engineering, and Mathematics (STEM) field, which has been implemented in Malaysian schools in the beginning of 2017.

The purpose of this research is to develop a media-based mobile learning to improve student HOTs. So, these results can provide an overview of how the stages of developing learning media with mobile blended learning can be applied in mathematics classes.

Literature Review

Mobile Blended Learning

Digital technology has changed the meaning of human beings. Mobility, online courses, massive open online courses (MOOCs), and modern technology have become an important part of our lives as mathematics teachers/lecturers, and it has become a daily lifestyle of 45% of the world's population who use the internet (Borba et al., 2016).

The concept of "mobile blended learning" in this study refers to an educational design that includes mobile devices for a learning combined with other learning educational approaches and technologies. Graham et al. (2013) use the term ‘blended learning’ as a combination of face-to-face learning and full e-learning that continues to increase at higher education levels around the world today. The results of research by Fisher and Kusumah (2018) show that blended learning can develop student characters, such as hard work, curiosity, and communication. Features that appear in learnings are clear evidence that this learning can not only improve students' cognitive abilities, but also the character of students. Researchers developed and used the concept of a mobile blended learning assisted by an android application, its name is "mastering math", because researchers hope that the use of a mobile learning with blended learning can be used not only for higher education, but also in primary and secondary education to improve HOTs.

High Order Thinking Skills (HOTs)

The general characteristics of HOTs indicate that there are non-routine and more complex thought processes that require great effort. HOTs promote sustainable learning and contribute various benefits to the country in the future. The core of HOTs is students' skills in problem-solving, questioning, reasoning, communication, and connection. The skills are needed by students in learning mathematics with good knowledge that is in themselves (Ansari et al., 2021; Madu, 2017).

HOTs capabilities include application, analysis, synthesis, and evaluation (Tambunan et al., 2019). To develop HOTs means developing conceptual understanding, communication, reasoning, creativity, and problem-solving so that students' learning achievement in mathematics can be determined by many factors including teacher competence in developing student HOTs. In accordance to this opinion, Tajudin et al. (2016) suggested that teachers should be able to integrate HOTs in mathematics; otherwise, students' abilities may be hampered by several factors, including the teacher's limited knowledge of HOTs. Not only that, but also students can develop the HOTs to be able to meet challenges of the 21st century due to their ability in the aspects of interpretation, analysis, evaluation, inference, explanation, and self-regulation (Saputri et al., 2019).

Implementation of HOTs in Indonesian schools applies Bloom's taxonomic order of thought, namely: Applying, Analyzing, Evaluating, and Creating; (Darmawan & Sujoko, 2013). Tambunan et al. (2019) showed that learning achievement and

students' mathematics learning in HOTs can be achieved well if the internal factors (students' interest and motivation in learning mathematics and external factors (use of learning approaches and implementation) are controlled properly.

Methodology

Research Design

This study is a type of development research because it develops a product that is an m-learning application (Indrawan & Yaniawati, 2014). The development procedure in this study adheres to the 4-D development (Four D) model of Thiagarajan (1974) which consists of four stages, namely (1) defining includes beginning-to-end analysis, student analysis, material analysis, task analysis, and specification of learning objectives; (2) the design includes media selection, format selection, and initial planning for mobile learning-based mathematics learning media with a scientific approach; (3) development and (4) dissemination.

Sample and Data Collection

The population is all grade VIII students of Yastrib Banjaran junior high school for the 2019/2020 academic year. The sample was taken by 30 students by random class sampling.

The instrument used is (1) a media expert validation questionnaire consisting of 13 statements consisting of three statements regarding aspects of use, seven statements regarding display aspects and three statements related to animation aspects. (2) a material expert validation questionnaire consisting of 16 statements consisting of five statements regarding the aspect of the suitability of the content with competence, nine statements about the learning aspect, and 2 statements about the task or exercise aspect. (3) a questionnaire on student responses to m-learning teaching materials as many as 26 statements, consisting of 16 statements regarding the feasibility aspect of presentation and 10 statement regarding the quality aspects of e-learning-based teaching materials. (4) creative thinking ability test questions as many as six questions in the form of descriptions given before and after learning. The test questions are arranged based on the type of creative thinking skills (fluency, flexibility, originality, and elaboration) which are described in the indicators of creative thinking skills, namely generating many ideas or ideas in solving problems or answers (questions no. 1 & 2, easy), answering questions in a variety of ways from different directions (question no. 3, easy), expresses unusual ways of expressing oneself (question no. 4, moderate), and develops or enriches the idea of answering a question (questions no. 5 and 6, difficult). The six questions on the creative thinking ability test are valid, because the calculated $\boldsymbol{r_{xy}}$ value is greater than the table $\boldsymbol{r_{xy}}$ value = 0.374 with the validity results as shown in the Table 1 and has a reliability value of 0.85 in the high category.

Table 1. Question validity score

Question Number	r_{xy} Value	Criteria
1	0,436	Valid
2	0,586	Valid
3	0,465	Valid
4	0,440	Valid
5	0,599	Valid
6	0,584	Valid

The instruments used in this research included a questionnaire for the validator of the m-learning teaching materials as many as 40 items, a questionnaire for students as many as 30 items, observation and interview guidelines, and six HOTs test questions in the form of essay. All of these instruments have been validated by experts and users with significant results described in the finding section.

Analyzing of Data

Data analysis techniques in this study were obtained from research instruments in the form of qualitative and quantitative data. Qualitative data were obtained from responses or suggestions from experts and students after using mobile learning-based teaching materials. Quantity of data obtained from questionnaires and HOTs tests. Qualitative data analysis technique using analytical descriptive. While the quantitative data were analyzed using the teaching materials feasibility test (Cochran's Q) and effect size.

Results

The results of research in the preparation of making learning media and instruments are as follows.

Phases in The Media Development Process

1. Define

Thiagarajan (1974) analyzed the five activities performed on the define phase, namely:

a. Front-end Analysis

The Indonesia Ministry of Education and Culture (Permendikbud, 2014) conveyed the refinement of the 2013 Curriculum as stipulated in number 160 of 2014. The refinement of the curriculum was linked to the challenges of 21st-century learning which requires learning to have a variety of skills for a career in life, learning and innovation, and technology and information media skills. One of the essences that were taken into consideration in the 2013 curriculum is the achievement of HOTs to solve problems by thinking critically, innovatively, creatively, for the sake of harmonious life.

HOTs-oriented learning requires students to find out which parts require intelligent and creative thinking processes. HOTs include analyzing, evaluating, creating, critical thinking, and problem-solving skills (Anderson & Krathwohl, 2001).

In the implementation of learning, teachers have not used technology optimally in improving student learning outcomes. As a result, students have difficulties in analyzing and constructing learning concepts, practicing communication skills in conveying ideas, and problem-solving skills. To obtain more effective learning outcomes in learning mathematics, an appropriate learning media is needed, especially using smart technology.

b. Learner Analysis

The results of the analysis of junior high school students show that at this time, they are used to using technology as most students have mobile phones.

Students' initial knowledge has not had an impact in building the new knowledge they have learned. In addition, teachers have not directed students to be actively involved in finding mathematical concepts and student's involvement; hence the lack of using learning technology media.

c. Concept Analysis

Based on the Focus Group Discussion (FGD) with the head of Education Authorities, m-learning experts, Council of Specific Subjects Teachers chairman, and mathematics teachers as many as 30 participants in West Java, Indonesia.

FGD meetings were conducted to obtain input from participants regarding the development of m-learning teaching materials (Indrawan & Yaniawati, 2014). There were some materials in which the concept could be built through the concepts in the previous material that had been absorbed by students. In this study, the topics to be discussed were Relations and Functions, the Pythagorean Theorem, Number Patterns, Straight Line Equations, Cartesian Coordinates, and Two-Variable Linear Equation Systems. These topics are essential material that must be mastered by students as the basis for understanding further material.

d. Task Analysis

Task analysis is carried out after studying the material to be delivered so that it can be seen what tasks the students must complete during the learning process. Thus, learning is more meaningful and effective.

e. Specifying Instructional Objectives

The material analysis and the tasks analysis are to generate specific learning objectives that are the basis for devising tests and designing teaching materials. The teacher then makes learning objectives based on the curriculum and on the needs and characteristics of the students.

2. Design

There are four stages of design activities, namely: building a criterion reference test, media selection, format selection, and initial design (Thiagarajan, 1974), as follows:

a. Arranging test criteria are in the form of an initial ability test on straight-line equation material to determine students' initial abilities. The test instrument is in the form of description questions oriented to HOTs. These questions contain interesting contextual questions.

b. Choosing learning media in accordance to the learning material and media are smartphones with Mastering Math application, with specifications of Minimum OS Android 4.4 (KitKat), which can be seen in Figure 1.

The choice of the presentation form of learning is adjusted to the application design that has been made into a template. The choice of format or presentation form includes Basic Competencies, Concept Maps, History, Materials, Summary, References, Posttests, practice questions, and quizzes which can be seen in Figure 2.

Figure 1. Mastering Math Application

Figure 2. Presentation form

Next, is to simulate the material presented through the Mastering Math application with learning steps that have been designed. As the learning simulation takes place, peer assessments are also carried out. One example of a straight-line equation presentation with material from the history of the inventor of the concept can be seen in Figure 3 and Figure 4.

Figure 3. Example of history of the inventor of the concept

Figure 4. Example of the contextual problem

3. Develop

a. Product Analysis Developed

The product analysis development consists of concept analysis, design analysis, and collecting of materials. At the concept analysis stage, an analysis of objects that were needed in the planning of learning tools was carried out. At this stage, it was decided that the topics used are Relations and Functions, Pythagoras Theorem, Number Patterns, Straight

Line Equation, Cartesian Coordinates, and Two-Variable Linear Equation System. The display logo of the Mastering Math application on a smartphone can be seen in Figure 5.

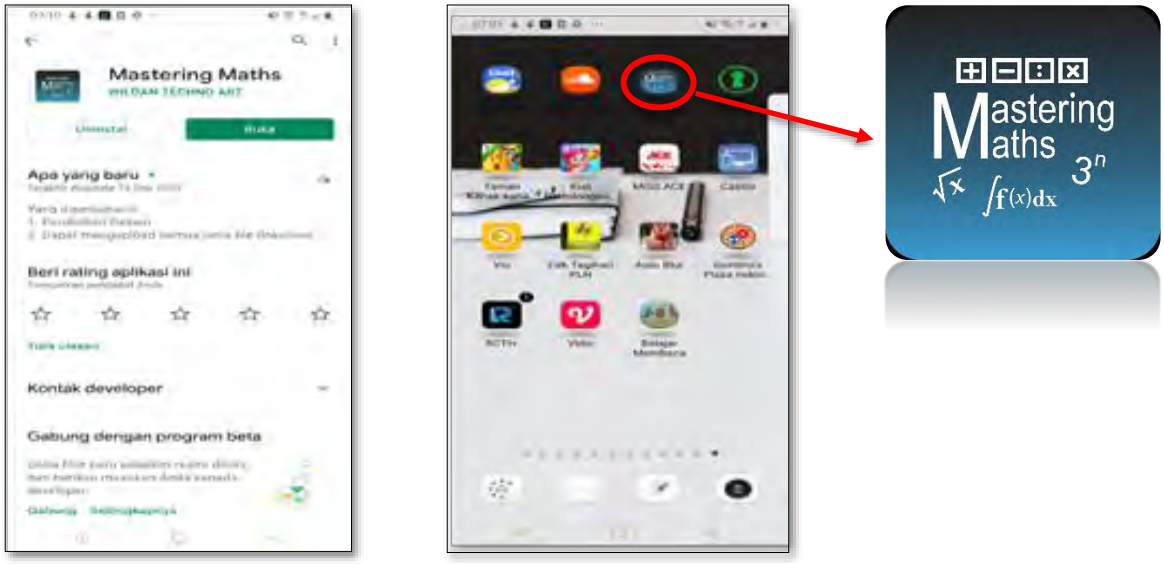


Figure 1. Initial display

Users can install the Mastering Math application with the above logo through the Playstore on an Android Smartphone. However, this application cannot be installed on iOS yet.

a. Media Validation Results (Mastering Math Application)

The results of the revision based on the validators' assessment produced a newly revised draft. In this study, there were 5 expert validators: mathematicians, mathematics education experts, and practitioners (teachers). Subjects for the limited trial were 16 persons, and for the more extensive trials, there were 30 persons.

Based on the validation and testing, the Mastering Math application is declared valid. Based on the Table 2 and Table 3 it can be seen that the application is feasible to be used in learning mathematics for straight line equations for students of junior high school VII grade. Assessment of applications by material experts includes the aspects measured are the suitability of content, learning, and assignments/ exercises with the results in the Table 2.

Table 2. The results of the material expert's assessment of the three aspects

Aspects	Material expert		Amount	Average
	I	II		
Contents suitability	3,4	4	7,4	3,7
Learning	3,8	3,6	7,4	3,7
Assigments/ Exercises	3,5	3,7	7,2	3,6
Total				11
Average				3,6
Category				Feasible

The assessment the application by media expert includes the aspects measures are the uses, display, and animation of the results in the Table 3.

Table 3. The results of the media expert's assessment of the three aspects

Aspects	Media expert		Amount	Average
	I	II		
Usage	4,0	3,3	7,3	3,6
Display	4,1	3,7	7,8	3,9
Animation	3,6	3,8	7,4	3,7
Total				11,2
Average				3,7
Category				Feasible

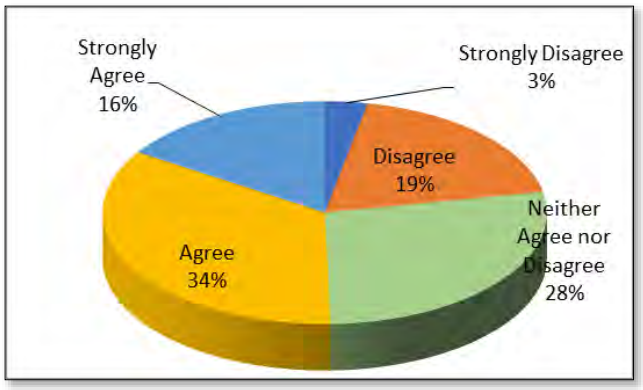


Figure 2. The result of Beta II Test

In the product trial process, large groups of data were collected, namely, student response questionnaire data after they use the learning teaching material. The student response questionnaire consisted of 2 aspects i. e. aspects of product feasibility, and aspects of quality of the teaching materials. The feasibility aspect consisted of 16 assessment items, and the quality aspect of teaching materials had 10 assessment items. Results of the Beta test on both aspects are in Figure 6.

In Figure 6 above, one can see that most of the students' responses at 34% agreed with the utilization of the Mastering Math application in learning mathematics on the subject of straight-line equations.

Results of validation trial by five validators are as follows:

1. Mastering Math application

The data obtained came from five validators of the Mastering Math application with the aspects being assessed are display, program, and learning. The Q-Cochran test was carried out to determine whether there were differences among the five validators. Table 4 shows the Q-Cochran test on the validation by the five validators on the teaching material and the learning.

Table 4. Result of the Q-Cochran

N	5
Cochran's Q	49.712[a]
Df	38
Asymp. Sig.	.097

a. 1 is treated as a success.

The Q-Cochran analysis technique was to determine whether there are differences between more than two related samples. The value of Asymptotic significance in Table 4 indicates 0.097 > 0.05 then the fifth validator gives the same assessment. In general, the validator states that the learning media is good and can be used with few revisions. The validator gave an average score of 96%. Based on the results of the expert validators, several revisions were made to the Mastering Math application which can be seen in Table 5.

Table 5. The expert validators

Media Before Revision	Media After Revision
Animation is not optimal, music and sound effects are not available, there is no audio material explanation yet, the video is not complete	Display and learning programs are developed by the advice of an expert validator

To measure the effectiveness of m-learning (Mastering Math) an effect size assessment was carried out with the results as shown in Table 6.

Table 6. Effect Size Assessment Results

Pretest Average	Posttest Average	Standard deviation	Effect Size	Criteria
34,3	77,6	16,89	2,57	High

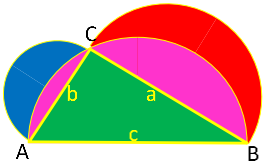
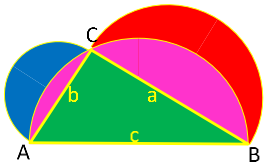
Table 6 shows that the effect size value is 2.57, which is included in the high criteria. This illustrates that the use of mobile learning-based teaching materials on straight-line equation material has a very significant effect on the mathematics learning process so that the use of mobile learning-based teaching materials is effective and able to increase students'

HOTs.

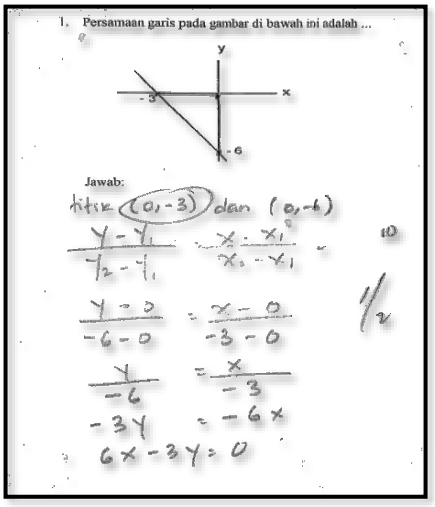
2. Learning Material

The learning material developed is a straight line equation that has been validated by several validators. In general, the validators state that the material is good and can be used with a few revisions. The validators gave an average value of 90.00%. In the experts' validation, some revisions were made to the media. See Table 7.

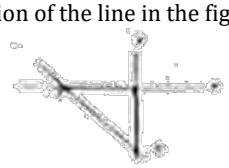
Table 7. Revised Mastering Math Application based on Validator Suggestions

Material Before Revisions	Material After Revisions
A point $P(3,2)$ lies on the line through the points $Q(-2,10)$ and $R = (1,1)$, so the value of d is ...	Given that a point $P(3,2)$ lies on a line through points $Q(-2,10)$ and $R = (1,1)$, then the value of d at point P is ...
The equation for the line $y + 9 + 20 = (p-1)x$ through the point $(7, p-2)$. The gradient of the line is ...	What is the gradient of a line if known equation line $y + 9 + 20 = (p-1)x$ which passes through the point $(7, p-2)$?
The image below is a drawing of a semi-circle area whose diameter is the side of the right triangle ABC.  Show that the area in blue plus the area in red equals the area in green.	The image below is a drawing of a semicircular area whose diameter is the side of the right triangle ABC that is a = 4 cm, b = 3 cm dan c = 5 cm.  Show that the area in blue plus the area in red equals the area in green.

HOTS questions on creative thinking abilities among indicators fluency at an average percentage of most students were able to work on the problems smoothly and answer the question correctly. The results of the answers are in Figure 7.



The equation of the line in the figure below is...



Answer :

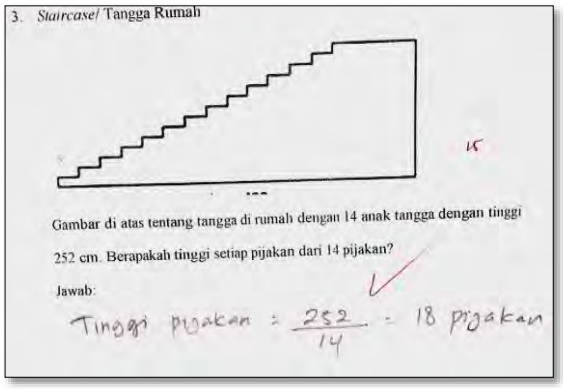
$x, y = (0,-3)$ dan $(0,-4)$

$$\frac{y-y_1}{y_2-y_1} = \frac{x-x}{x_2-x_1}$$
$$\frac{y-0}{-6-0} = \frac{x-0}{-3-0}$$
$$\frac{y}{-6} = \frac{x}{-3}$$
$$-3y = -6x$$
$$6x - 3y = 0$$

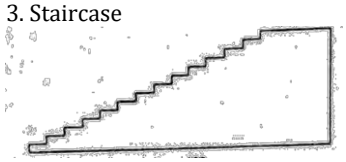
Figure 3. Student Answers to the Fluency Indicator

In figure 7, one can see that the student is still not careful in working on the problem so that the student cannot work on the problem smoothly even though he can solve the problem completely but the student's answer is still not correct.

On average flexibility indicator of the percentage of students almost all students can work on the problems in a flexible way and able to mention as well as working on other ways to solve a problem and were able to answer the question correctly. The results of students' answers are in Figure 8.



3. Staircase



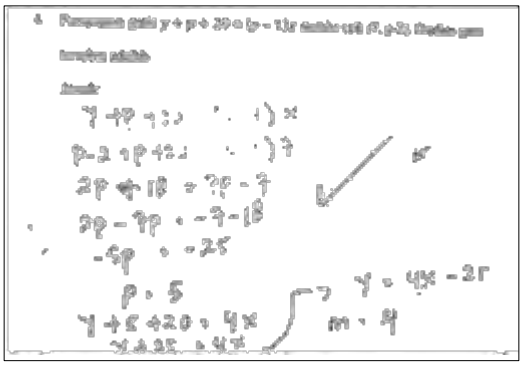
The picture above is about a staircase in a house with 14 steps with a height of 252 cm. What is the height of each of the 14 steps?

Answer :
footing height = $\frac{252}{14} = 18$ steps

Figure 4. Student Answers on the Flexibility Indicator

In Figure 8, it can be seen that a student has been able to work on the problem flexibly and finish the problem with the correct answer.

On the originality indicator, the average percentage of students shows almost all students can work on new problems that have never been encountered before in a unique way and answer the question correctly. The students' answers are in Figure 9.



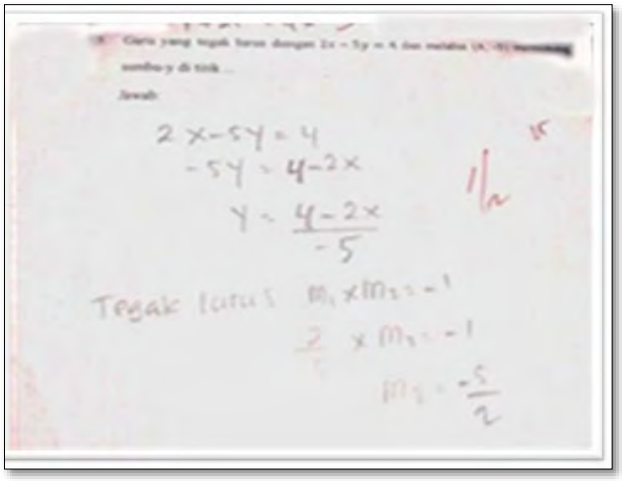
4. The equation of the line $y + p + 20 = (p - 1)x$ through the point $(7, p\text{-}2)$. The gradient of the line is...
Answer :

$$y + p + 20 = (p - 1)x$$
$$p - 2 + p + 20 = (p - 1)7$$
$$2p + 18 = 7p - 7$$
$$2p - 7p = -7 - 18$$
$$-5p = -25$$
$$p = 5$$
$$y + 5 + 20 = 4x$$
$$y + 25 = 4x$$
$$y = 4x - 25$$
$$m = 4$$

Figure 9. Students' Answers on Originality Indicators

In Figure 9 one can see that students were able to work on the problems in their way where the calculation process can be understood and lead to the correct answer.

In the elaboration indicator, the average percentage of students shows that some students are still less able to develop ideas to solve problems in detail and to answer the questions correctly. Results of the students' answers are in Figure 10.



The line perpendicular to $2x - 5y = 4$ and through $(4, -5)$intersects the y-axis at the point ....
Answer :

$$2x - 5y = 4$$
$$5y = 4 - 2x$$
$$y = \frac{4 - 2x}{-5}$$

Perpendicular : $m_1 \times m_2 = -1$

$$\frac{2}{5} \times m_2 = -1$$
$$m_2 = \frac{-5}{2}$$

Figure 10. Student Answers on Elaboration

4. Dissemination

The dissemination phase is carried out in collaboration with the West Java provincial education office so that it can be used by mathematics teachers and students. Packaging material must be selective in order to produce the right shape. The development of online learning media is supported by multi-representation-based learning media from the availability of facilities and infrastructure. Supporting facilities in the room are projectors, laptops, and internet networks (Wifi). The applications can be downloaded to a smartphone, so they can be accessed anytime and anywhere using the smartphone. The inhibiting factor for the development of instructional media is in the making animation videos which require a long time and demand accuracy.

The product of this development has advantages, among others are: (1) mobile blended learning media used by junior high school students will maximize students' limited learning time; (2) mobile blended learning through the Mastering Math social media application can make it easier for students to do online learning anywhere and anytime provided they can be connected to the internet; (3) The use of mobile blended learning media through the Mastering Math application is not boring because it contains texts, images, audio and videos which can increase students' interest in learning mathematics.

Some shortcomings are: (1) the use of mobile blended learning media through the Mastering Math application must be accessed using media connected to the internet; (2) It should provide insight to the user, in this case, students and teachers, regarding the use of applications.

Discussion

The process of developing instructional media using the Thiagarajan theory (1974) goes through several stages: (1) define; (2) design; (3) development and (4) dissemination. At the defining stage, the determination pays attention to preliminary-to-final analysis, student analysis, material analysis, task analysis, and specification of learning objectives. The definition stage is the first step in determining the mathematics learning media in the form of the Mastering Math mobile learning application and research instruments to obtain prototypes (mobile learning scientific-based mathematics learning media and research instruments). By the opinion of Fauziyah and Triyono (2020), the formulation of indicators for the achievement of learning outcomes is the basis for knowing what will appear in the learning device, and ultimately determining how much learning objectives can be achieved.

In the second stage design, the researcher conducts consultation with media experts in making it so that they can design the learning media. Activities carried out at this stage are (1) media selection, (2) format selection, and (3) initial planning for mathematics learning media. The learning media design that is made must meet the characteristics of active learning. Işman (2011) said that a good learning design model is based on active learning. It is expected that during teaching and learning activities, students are active and apply cognitive learning to build new knowledge, gathering new knowledge, and learning by using technology. These materials are related to goals and objectives. The learning material developed is a straight line equation. This material was developed with a HOTs orientation so that after the students learn through this Mastering Math application, it is expected that their students' HOTs abilities will improve. HOTs is required by students in dealing with contextual problems and related to everyday life. This is in line with the results of Yaniawati et al. (2019) which states that when students master mathematical connection and communication skills, they will be able to face many contextual problems.

At the development stage, a draft of the mathematics learning media is produced with the Mastering Math application. It is an application designed to be integrated into a mobile phone. This application was developed for junior high school students. Learning to use mobile learning is suitable for 21st-century learning, especially the characteristics of learners today this is consistent with Seechaliao's (2017) opinion that the learning strategy uses social media and mobile devices, as learning equipment. It can sustain the learning style of digital learners and increase their learning motivation. To obtain an effective media and interactive learning of the material that has been determined necessary interface design is designed to enable researchers to implement in the form of a programming language or the animation to be created. In addition, Grant (2019) state that the development of mobile devices is very rapid, and their use in education, personal learning, and in the workplace is having a considerable impact.

Activities carried out at this stage involve expert judgment and legibility testing. The designed instructional media are validated by media experts for input and suggestions. The readability test is also carried out in terms of sentences and language.

The validator's assessment of the m-learning teaching materials is in the good category and these teaching materials can be used after going through minor revisions. Learning materials have been prepared for use in the field in accord with the latest curriculum, the Curriculum of 2013, and it is hoped that when it is tested it will produce good results from students' and also of teachers as the HOTs increase.

The following stage is dissemination, at this stage, several factors support and hinder the process of conducting the research. Among them are factors of adequate infrastructure with educational infrastructures that motivate learning activities, to increase student satisfaction and elevate teacher performance. Another consideration for the use of

infrastructures is to foster interaction in the classroom and the sustainable development of educational institutions (Setyaningih, 2018).

The advantages of blended learning according to Utari et al. (2020) are that students can obtain information without having to face the teacher directly, while increasing student curiosity about information, flexible learning, and can reduce costs in the learning process. Apart from having several advantages over face-to-face and online learning, hybrid learning also has several drawbacks. In general, the shortcomings of blended learning include: (1) the required media is different and is hard to adjust if the tools do not sustain it; (2) unbalanced tools that students have, as well as computers and internet access, as blended learning requires adequate internet, it certainly is hard to students to take part in online independent learning; (3) the insufficiency of knowledge of human resources (teachers, students and parents) on the applying of technology. In addition, teachers need to set up a time to develop and manage online learning systems, such as developing materials, preparing the assessment, conducting the assessment, and providing answers or giving statements on the forum presented by the students (Butar-butar et al., 2018).

Based on the results of the study showed that students experienced an increase in HOTs after using the Mastering Math application. This is in line with the opinion of Jihad et al. (2018) which states that m-learning is not only a supplement but can also help students do exercises so that they can improve their learning outcomes.

Conclusion

In developing mobile learning-based media to increase the students' HOTS, there are 4 stages in the Thiagarajan methods i.e. (1) define; (2) design; (3) development, and (4) dissemination. Defining the curriculum, which includes HOTs, then conducting learner analysis through the documentation and literature study. At the design stage, there are 4 activities carried out, that is arranging instruments, selecting media according to the characteristics of students, choosing learning formats, and conducting simulations. So, these results can provide an overview of how the stages of developing learning media with mobile blended learning. The next stage is the development stage, starting with validating the product, which aims to obtain the requirements needed in learning by analyzing the goal and limitations of the material; then obtaining the initial draft I which is then validated by experts and revised to deliver draft II. M-learning teaching materials in mathematics subjects, especially straight-line equations for junior high school students, are produced in the form of applications that can be used on Android smartphones which can be utilized as a learning material to support learning mathematics. The resulting m-learning teaching material is equipped with text, images, and animation content. In addition, the product of m-learning teaching materials consists of components which include; home page, basic competence, concept maps, history, summary, references, posttest, exercises, and sub-chapter material. The content of the material contains learning objectives, contextual problems, and learning materials. Exercise questions are presented in each sub-chapter of the learning material, in multiple-choice tests, which aim to assess students' cognition of the material that has been studied. The developed m-learning teaching materials are categorized as suitable for use. The effect size is included in the high criteria, so that the use of mobile learning-based teaching materials is effective and able to increase students' HOTs.

Analysis of students' creative thinking in learning straight-line equations, after receiving m-learning-based learning media, on average, the students increased drastically, this was seen from the results of the students' answers showing they could answer almost all questions correctly even though there were still some students who still difficulties had to answer the questions. Overall, the highest percentage of creative thinking ability achievement is in flexibility and the lowest is in elaboration.

This research implies that the learning is better because it can be done anywhere, anytime, and is suitable for student characteristics. In addition, students' divergent thinking develops, and their learning motivation of mathematics increases.

Recommendations

In order for the m-learning system to be effective and efficient, teachers need to pay more attention to the teaching materials & e-learning systems developed, the readiness of students to conduct e-learning, as well as supporting facilities and infrastructure such as internet connections and computers/mobile phones used in compatible learning. with the computer application used. E-learning systems and teaching materials need to be developed carefully and use communicative and interesting language. Teachers can work with IT experts to make the animations needed to make them more interesting. In addition, teachers need to think about technical problems that often occur and prepare solutions. For further research, it is necessary to develop an m-learning system by integrating various applications that can increase student motivation in learning. These applications can be in the form of Augmented Reality (AR), Virtual Reality (VR), educational games, and others.

Limitations

The research objects that are represented here are limited to junior high school class VIII teachers and students on the topics in Relations and Functions, Pythagorean Theorem, Number Patterns, Straight Line Equations, Cartesian

Coordinates, and Two-Variable Linear Equations System. In addition, the operating system of the Mastering Math application is limited to Android, so it cannot be used on iOS.

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Author Contribution Statement

Yaniawati: Conceptualization, design, analysis, writing, final approval, securing funding. Maat: Analysis, supervision, acquisition. Supianti: Editing/ reviewing, supervision. Fisher: Editing/ reviewing, supervision.

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