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Development and effectiveness of mobile learning teaching materials to increase students' creative thinking skills

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Abstract. This study aims to develop mobile learning (m-learning) teaching materials on straight-line equations and analyze its effectiveness in increasing junior high school students' creative thinking skills. The method used is the R&D developed by Alessi and Trollip. The stages of this research include planning, design, and development. The planning stage includes determining the scope, identifying existing teaching materials and student characteristics, and collecting references. The design stage includes analysis of the material concept, making flowcharts and storyboards of teaching materials. The development stage includes preparing teaching materials through expert validation and two trials, making mobile learning applications, and evaluating teaching materials to analyze their effectiveness. The teaching materials were evaluated by material, and media experts then tested on 30 students. The m-learning teaching material developed is an Android smartphone application that students can use as a support source for learning mathematics. This study's subjects were all class VIII Yastrib Junior High School students, as many as 30 people. The results showed that the m-learning teaching materials on straight line equations developed were feasible to use. Their effectiveness in developing creative thinking skills in the learning process was considered adequate for students with an effect size value of 2.51, which was in the very high category.

1. Introduction

In the current era of globalization, many technologies can be used as learning media in the mathematics learning process, mobile learning. Combining telecommunications and internet technology enables the development of a mobile learning system as a learning medium [14]. Mobile learning technology in developing countries like Saudi Arabia is considered an effective tool in enhancing communication and learning. Technology like mobile learning has tremendous potential, which can strategically support and enhance student relations [2]. This is consistent with research [10] on the Development of a Mobile Service, a Wifi Network for the Evaluation of Mathematical Skills, which shows that the development of an online evaluation system via mobile phones makes the assessment process more accessible and more effective. Mobile learning technology is currently being developed; however, mobile learning technology as a learning medium is one of the future technologies.

Mobile learning technology can be used in education because almost all students from elementary, junior high, and high school levels already have cellphones. But in reality, the use of mobile phones as telecommunications today is still not optimally utilized in education. Whereas the use of mobile phones as learning media is certainly interesting and practical as it can be accessed anywhere and at anytime [7]. This is consistent with research [10] on MoMath: An Innovative Design of a Mobile-based System



for Supporting Primary School Mathematics in Tanzania, which shows that more than 50% of teachers and students in primary schools in Tanzania like MoMath because it is easy to access and to be used everywhere

Mobile learning is a relatively new tool in the pedagogical arsenal to support students and teachers as they navigate the options available in the expanding world of distance learning [2]. The m-learning systems are not to replace traditional classrooms, but they can be used to complement the learning process in our schools and universities [19]. With the help of mobile learning, students can better understand the learning material, students do not get bored easily, and students can repeat the learning material anywhere.

Creativity has growing significance in the contemporary world received increased attention in recent educational reforms around the world [25]. That is, recently there has been a significant increase in attention to educational reform on creativity around the world. Future challenges that are always changing as well as increasingly fierce competition, require educational output that is not only skilled in a particular field but also creative in developing the occupied field [5]. Older children still need time for reflective abstraction, and they also need their parents and teachers to pay attention to them and support their creative thinking [8]. A person's creative learning environment can affect academic achievement, motivation, involvement, and thinking skills of students [3]. Creativity and the use of technology are very important skills [9]. Using and teaching information and communication technology can help maximize creative thinking skills [11]. The ability to think creatively is one of the learning objectives listed in the Law Number 20 of 2003 concerning the National Education System [21].

The ability to think creatively in solving math problems can be assessed by the three components namely fluency, flexibility, and novelty. A student demonstrates fluency, flexibility, and novelty in problem-solving by the ability to explore different strategies and solutions to open-ended questions and generate new problems [18]. The ability to think creatively can be developed in a student-centered learning environment, which provides space to cultivate intellectual and independent thinkers [23]. Applying Android-based educational games as a learning medium can help children in learning and can improve creative thinking patterns and increase more advanced knowledge in early childhood [15]. Learning strategies based on mobile learning are more interactive, fun, and very effective in achieving learning goals [13].

The integration of e-learning into resource-based learning methods results in better improvements in mathematical creative thinking skills and in the development of self-confidence in learning that does not apply e-learning [26]. Student learning outcomes using mobile learning with the help of Android XI smartphones are classically complete with a percentage of 80.64% in class XI Senior High School 1 in Nganjuk, Indonesia. [6] Public Senior High School 8 in Surakarta, supported by the mean score of students in the experimental class at 82.72 higher than the control class at 77.12 [24]. The scores of students' creative thinking abilities that exceeded the minimum completeness criteria score of 76 were more than 75% of all students who used the problem-based learning model assisted by interactive media [16]. Students' creative thinking skills during the learning process were classified as good and experienced an increase, as well as student understanding using flipbook media [12].

The development of mobile learning applications as a learning medium can improve creative thinking skills where the achievement of increasing students' creative thinking skills in the experimental class is higher than the control class [2]. The development of m-learning teaching materials for high school physics learning can improve creative thinking and problem-solving skills which can be seen based on the gain values of 0.81 and 0.96 which are in the high category and have a large effect on this learning as seen from the effect size with a score of 0.268 and 0.269 [17]. Learning with mobile learning is more effective in improving students' critical thinking skills in the mathematics education study program at the PGRI University of Semarang [14]. Based on the description above, the authors conducted research by making mobile learning based teaching materials to improve students' creative thinking skills.

2. Methods

The research method used is research and development, namely, the research method used to produce specific products; the product produced in this study was a teaching material based on mobile learning on straight line equation material to improve 30 grade VIII students' creative thinking. The design used in this study was the One Group pretest-posttest design, which consisted of an experimental group without a control group. This design compared the test scores before using teaching material with the test scores after using the teaching materials. This research's development procedure was proposed by Alessi and Trollip [22], i.e., Planning, Design, and Development. The instruments used were validation sheets, attitude scale questionnaires, and creative thinking skills test questions.

3. Results and Discussion

3.1. Results of the assessment of two material experts

The data obtained from the validation results by material experts are converted on a scale of 1-5. Based on the processed data results, the average score for the assessment by material experts on the aspect of content suitability was 3.7 out of 5 validated items and included in the feasible category. In the learning aspect, 3.7 out of 9 items were validated and included in the feasible category. Meanwhile, in the task/training aspect, 3.6 out of 3 items were validated and included in the feasible category. Information regarding the material expert's assessment is presented in Table 1.

Table 1. Results of the assessment of two material experts on the three aspects

Aspect	Material Expert		Sum	Average Score
	I	II		
Content suitability	3,4	4	7,4	3,7
Learning	3,8	3,6	7,4	3,7
Assignments / Exercises	3,5	3,7	7,2	3,6
Total number				11
Average Score				3,6
Category				Worth it

3.2. The assessment of two media experts

Data obtained from the results of validation by media experts are converted into a scale of 1-5. Based on the results of the processed data, the average score of assessment by media experts on the aspect of use is 3.6 out of 3 validated items and falls into the feasible category. In the display aspect, 3.9 out of 7 items were validated and included in the feasible category. Whereas in the animation aspect, 3.7 out of 3 items were validated and included in the feasible category. Information regarding the media expert's assessment is presented in Table 2.

Table 2. Results of the assessment of two media experts on the three aspects

Aspect	Media Expert		Sum	Average Score
	I	II		
Use	4,0	3,3	7,3	3,6
Display	4,1	3,7	7,8	3,9
Animations	3,6	3,8	7,4	3,7
Total number				11,2
Average Score				3,7
Category				Worth it

3.3. Research Product Development

The result of the development of m-learning teaching materials is a mathematics learning application for junior high school students, a class VIII on straight line equations. The menu display and sample material in the m-learning application can be seen in Figure 1 below.

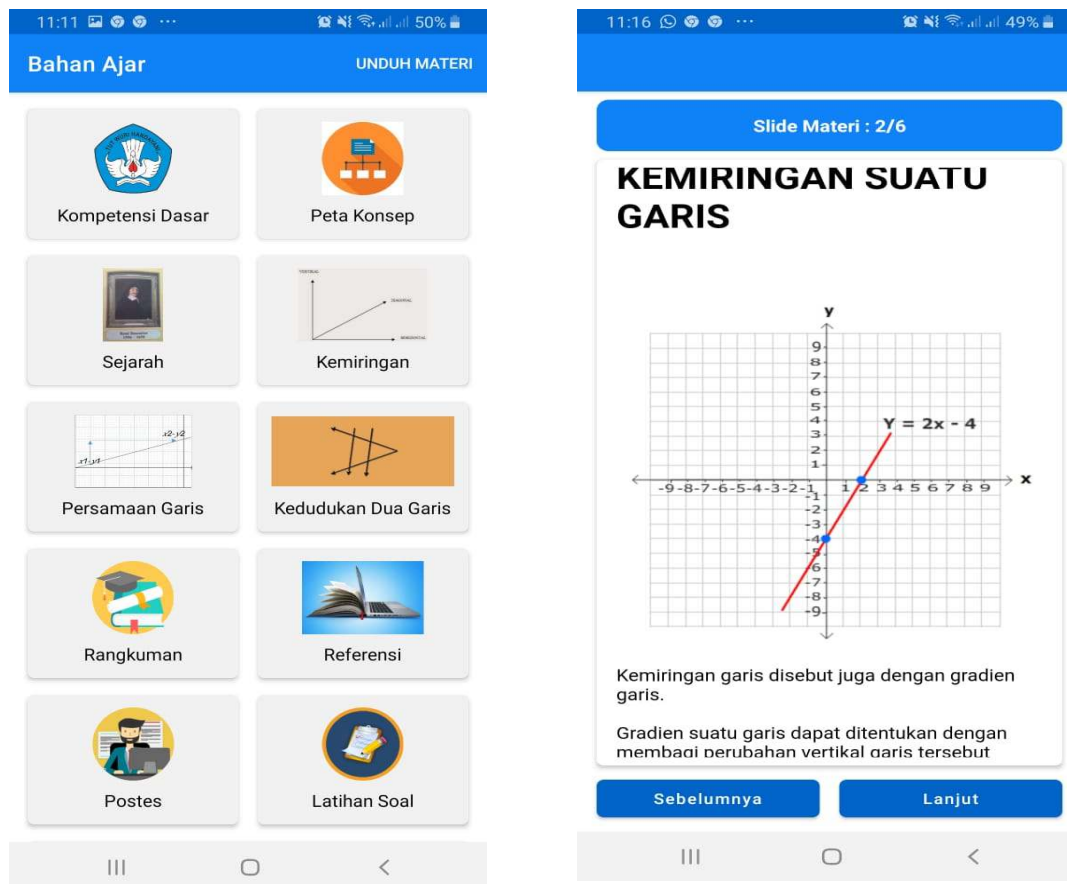


Figure 1. Display menu and material on m-learning teaching materials

This m-learning teaching material includes nine main menus: basic competencies, concept maps, history, material, summaries, references, post-tests, practice questions, and quizzes. The primary competency menu contains the basic competencies that will be achieved after students learn to use this m-learning teaching material. The concept map menu is used for students to understand more in detail the material to be explained. The history menu contains the history of the inventor of straight-line equation material; the material menu contains material covering three topics, namely, slope, straight-line equations, and the position of two lines from each discussion of the material are always equipped with contextual problems and learning objectives. Also, there are always exciting animations, so students don't get bored with learning the teaching materials. The summary menu contains the essence of each topic of material discussion; the reference manual contains references taken in making m-learning teaching materials; the post-test menu contains essay test questions for students; the exercise menu contains questions consisting of 30 questions, each group of 10 questions for each topic. After finishing the work, the user can find out the acquisition of the score, and the user can try again if they are not satisfied. The quiz menu contains multiple-choice questions from all sub-chapters that are randomly randomized and use the time duration in the process to evaluate students' abilities after studying the material.

3.4. The effectiveness of teaching materials

The effectiveness of m-learning teaching materials on creative thinking skills is measured by giving pre-test and post-test questions, namely by looking at the difference in scores before and after using teaching material products. The pre-test and post-test activities were carried out after the extensive group test. The m-learning teaching materials had been revised based on suggestions from material experts, media

experts, and 8 students. To determine the effectiveness of teaching materials on the creative thinking ability of the writer using a formula *effect size, one simple group t-test*. Information on the effect size assessment can be seen in Table 3.

Table 3. Rating result *effect size*

Group	Average Pre-test	Average Post-test	Standard Deviation	Effect Size	Criteria
	34,3	77,6	16,89	2,57	High

Table 3 shows that the effect size's value is 2.57, which is included in the high criteria. This illustrates that using teaching materials based on m-learning on straight line equation material has a very significant effect on the mathematics learning process. Also, the use of teaching materials based on m-learning is more effective and can improve students' creative thinking skills.

Results of observations on the mathematics learning process at Yastrib Senior High School in Banjaran, Indonesia, show that students are less enthusiastic in participating in the mathematics learning process because the learning strategies applied to tend to use an expository approach and are often fixated on teacher-centered learning or only teachers are the source of student learning. After obtaining information about the scope of students' boundaries and characteristics, the developer creates a planning document regarding the material and other things needed to make a product. From the syllabus of mathematics subjects and student learning outcomes, it was found that students still encountered difficulties, then determining straight line equation material as the material to be presented in this learning teaching material product. The application of teaching materials based on m-learning is considered adequate for students. This can be seen from the effect size value of 2.57, which is included in the high criteria. This illustrates that using teaching materials based on m-learning on straight line equation material has a high effect on students' creative thinking abilities. This is in line with [14], who stated that learning with m-learning is more effective in improving students' critical thinking skills of the PGRI University of Semarang mathematics education program.

3.5. *Students responses*

The results of the student questionnaire responses showed in Figure 2 that 34% of the 30 students who were the subject of learning research said that they agreed that m-learning teaching materials could facilitate the learning process of mathematics and could be easily understood. It can be seen that m-learning can improve students' creative thinking skills. According to the opinion of Yaniawati et al. [27] that e-learning can develop students' creative thinking in mathematics learning.

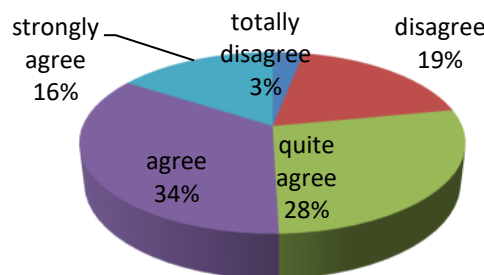


Figure 2. Student Response Results

4. Conclusion

M-learning teaching materials are developed through three stages, namely planning, design, and development. The m-learning teaching material developed according to two media experts' assessments based on three aspects: use, appearance, and animation. The m-learning teaching materials are developed

through three stages, namely planning, design, and development. The m-learning teaching materials developed according to the assessment of two media experts based on three aspects: use, appearance, and animation in the feasible category. Thus, based on the assessment of media experts, m-learning teaching materials were suitable for use. In addition, the assessment of the two material experts based on three aspects, namely the suitability of content, learning, and assignments, has an feasible category, thus based on the expert's judgment, m-learning teaching materials are suitable for use.

The application of m-learning based teaching materials is considered effective in terms of improving student learning outcomes, so that increase creative thinking ability. Students who have achieved minimum completeness criteria more than 70% indicate that the use of m-learning based teaching materials on straight line equations have a significant effect on the mathematics learning process with high criteria.

This research recommends that in using m-learning teaching materials, the teacher should refer to learning indicators based on student characteristics and the times. Also, before using the m-learning application, students are given training first.

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