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Development of Interactive Multimedia as Support in Learning Mathematical Problem Solving for Junior High Schools

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Abstract:- The essence of learning mathematics is the ability to solve problems. This study aims to develop appropriate interactive multimedia in the class VIII circle material, in terms of validity, practicality and effectiveness. The method used is the Research and Development (R&D) method with the ADDIE model. The test subjects were the students of State Junior High School 15 Banjarmasin. Data collection techniques used were tests and questionnaires, with data analysis techniques using descriptive statistics. The results of the research obtained interactive multimedia on circle material developed using HTML, CSS, JavaScript, Firebase Realtime Database, JSON, GeoGebra, Scratch, MathJax, and Netlify technologies. The developed multimedia is declared valid in terms of material, media, practical, and effective. Thus, this interactive multimedia is suitable for use for circle learning in class VIII.

Keywords:- *Development; Interactive Multimedia; Mathematical Problem Solving.*

I. INTRODUCTION

One of the graduation competency standards for mathematics is the ability to solve problems. In learning mathematics, problem solving skills are very important both for studying mathematics itself and for understanding that mathematics can be used to expand knowledge and to solve problems in various fields. Therefore, the core of learning mathematics is the ability to solve problems. Through learning mathematics, the ability to think logically, analytically, critically, creatively and carefully as well as objectively in solving problems can be developed [21]. In addition, in learning mathematics, students are introduced to relationships and generalization patterns from everyday experiences so that it is expected to increase their creativity and awareness of the socio-cultural development of the surrounding community [1]. As a result, Mathematics is studied at all levels of education including in junior high school.

Mathematics learning in junior high school is the foundation for learning mathematics at advanced levels, especially at high schools. In fact, based on the research results [3][5] as well as research results [10], the mathematical problem solving ability of junior high school students is still low. Meanwhile, the results of the PISA (Program for International Student Assessment) test in 2018 Indonesian students achieved an average score of 379, far below the international average of 489. Since the character of PISA questions in general is problem solving, the low score achieved indicates that the mathematical problem solving ability of junior high school students in Indonesia is still low [8]. Likewise, the results of a study [13] of junior high school students in Central Kalimantan showed that only 1.91% of students had the expected abilities as good problem solvers. So that action is needed to improve the ability of students in solving mathematical problems. According to [13] efforts to improve students' ability to solve mathematical problems is to increase the factors that influence it, including by improving the quality of learning media.

Learning media are teaching aids for teachers to deliver teaching materials, increase students' creativity, and increase students' attention in the learning process [14][20]. The use of learning media is expected to increase students' learning motivation so that learning becomes more effective and efficient. In the end, it is hoped that it will have an impact on increasing the ability of students to solve mathematical problems. Current technological developments allow and require teachers to utilize information technology-based learning media.

It is undeniable that the interest of students in technology today is very large. School-age children are no stranger to technological devices such as computers, laptops, or gadgets. Improving the quality of learning with the application of ICT (Information Communication and Technology) can be done by developing learning applications in interactive learning models that are fun and exciting for students. The dynamic nature of computer use is an important key to introducing cognitive play activities [17]. The development of interactive multimedia is one way to prepare technology-based learning media.

Interactive multimedia is a computer-based media which is a combination of images, video, animation, and sound in one software, which allows reciprocal communication between media and users [6][14][19]. Several studies have shown that the use of interactive multimedia in learning mathematics makes learning more

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fun so that students are more motivated to learn [9][11][12][18]. The use of animation in interactive multimedia can help students visualize abstract mathematical concepts so as to improve students' thinking which in turn can help them understand mathematical concepts [2][16]. However, the ability of students to solve mathematical problems in learning using interactive multimedia remains under studied. Based on the background that has been described, it is necessary to develop interactive multimedia to support the mathematical problem solving ability of junior high school students. In this case, it is focused on the circle material in class VIII.

II. METHODOLOGY

A. *Research Goal*

This study aims to develop interactive multimedia that is suitable for use in circular learning in class VIII. This media is expected to help teachers in creating fun and student-centered mathematics learning, so as to improve students' mathematical problem solving abilities.

B. *Research Design*

The research method that would be used in this research is the Research and Development (R&D) method and the development model that would be used in this research is the ADDIE model. In general, there are five development steps, namely analysis, design, development, implementation, and evaluation.

a) Analysis
The analysis stage is the stage for analyzing needs which includes general analysis, material analysis, and technology analysis. The purpose of this stage is to determine the scope of the material, the characteristics and presentation of the material, how the interactivity is on the media, how the user interface is, knowing the technology and tools needed, and knowing the system requirements.

b) Design
The next stage is to make a design of interactive multimedia that will be developed. Activities at this stage consisted of compiling content, designing interfaces and databases. All designs are evaluated so that during development there are no obstacles. The design of the application content in the form of a teaching material module, after being evaluated by the entire research team, was then validated by three mathematics education experts from Lambung Mangkurat University (ULM). Database interface and design evaluated by the whole research team.

c) Development
After all the designs are improved according to the results of the evaluation, then the interactive multimedia development is carried out. The results of the development were evaluated by all team members, then validated by two media experts from the ULM Computer Education Study Program. After being declared valid, it can proceed to the next stage, namely the implementation stage.

d) Implementation
At the implementation stage, a trial of the use of multimedia in learning was carried out. The trial was conducted offline at State Junior High School 15 Banjarmasin. The test subjects were 15 students of class VIII at State Junior High School 15 Banjarmasin. From the test results, it can be seen the practicality and effectiveness of the developed learning multimedia.

e) Evaluation
Evaluation is carried out at the end of each stage. The evaluation was carried out by all research teams by involving parties outside the competent team. To avoid obstacles in development, the next stage is carried out if the evaluation results have been followed up. Thus, multimedia will be obtained that is suitable for use.

The feasibility of learning media is reviewed based on validity, practicality and effectiveness (Nieveen, 2010). Multimedia is said to be feasible to use if it is declared valid, practical and effective. Validity is seen based on the validity of the material and the validity of the media. Material validation is assessed based on three observed aspects, namely content feasibility aspects, presentation feasibility aspects, and linguistic feasibility aspects. The material validation instrument was adapted from the *Badan Standar Nasional Pendidikan* (BSNP, n.d.). Media validation is assessed based on three aspects, namely Feedback and Adaptation, Presentation Design, and Interaction Usability. The media validation instrument was developed with reference to the instrument developed by (Nesbit, Belfer, & Tracey, 2009). The practicality of the developed multimedia is measured through the response from the user. The user response questionnaire is an adaptation of the student response questionnaire from [18]. Responses were given to aspects of ease of use and navigation, content of cognition, scope of knowledge and presentation of information, aesthetics, overall function, and ease of learning. The effectiveness of the developed multimedia is seen from the problem-solving abilities achieved by students after learning with the help of this media. The test instrument for the ability to solve mathematical problems consists of three essay questions on the VIII class circle material. The indicator of mathematical problem solving ability used refers to (Polya, 1973), which consists of: (a) Understanding the given problem, (b) making plans to solve problems, (c) implementing the planned problem solving, (d) interpreting and recheck the results obtained.

The data analysis technique used is descriptive statistical analysis. The assessment of material and media validation uses a ratting scale with a score range of 1 to 4. With a description of the score 1 means very poor, score 2 means poor, score 3 means good, score 4 means very good. Based on the score

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achieved, then the average achievement (AA) is calculated, with the formula

$$RC = \frac{total\ score\ achieved}{many\ items * many\ respondents} * 100$$

Furthermore, to determine the validity criteria, the AA value was consulted with Table 1. The multimedia developed was said to be valid in terms of material, if the validity criteria reached high with a minimum AA value of 3. The same also applies to media validity.

Average Achievement (AA)	Criteria
1 ≤ RC < 2	Very Low
2 ≤ RC < 3	Low
3 ≤ RC < 4	High
RC = 4	Very High

Table 1: Criteria of validity and practicality

To test the practicality, the user response instrument was designed using a Likert scale. User responses are scored with a range of 1 to 4. A score of 1 means strongly disagree, a score of 2 means disagree, a score of 3 means agree, a score of 4 means strongly agree. Based on the score achieved, the AA is calculated. Furthermore, the AA value is consulted with Table 2. The multimedia developed is said to be practical, if the user's response reaches a minimum AA of 3 with positive criteria.

Average Achievement (AA)	Criteria
1 ≤ RC < 2	Very negative
2 ≤ RC < 3	Negative
3 ≤ RC < 4	Positive
RC = 4	Very Positive

Table 2: User Response Criteria

The effectiveness of the media is seen based on the mathematical problem solving ability of students. The initial ability of students is seen from the results of the pretest, and the final ability is seen from the results of the post-test. The criteria for students' mathematical problem solving abilities are based on Table 3.

Score	Criteria
0 ≤ Score ≤ 20	Very poor
20 < Score ≤ 40	Poor
40 < Score ≤ 60	Fair
60 < Score ≤ 80	Good
80 < Score ≤ 100	Very Good

Table 3: Mathematical problem solving ability criteria

Adapted from Arikunto (2015)

Based on the pretest and posttest values, the N-Gain value is then calculated. The N-Gain test is used to measure the improvement in problem solving skills between before and after learning with the help of interactive multimedia. The value of N-Gain (g) is calculated by the formula (Hake, 1999).

$$g = \frac{Posttest\ score - Pretest\ score}{100 - Pretest\ score}$$

Furthermore, the average value of N-Gain is calculated. The criteria for the average N-Gain value are determined based on Table 4. The multimedia developed is said to be effective if the average N-Gain value is at least on the medium criteria, and the average mathematical problem solving ability of students is at least on good criteria.

Scale	**Criteria**
g > 0.7	High
0.7 ≥ g ≥ 0.3	Low
g ≤ 0.3	Low

Table 4: N-Gain Value Criteria

III. RESULT AND DISCUSSION

A. *Results*

This research has succeeded in developing interactive multimedia on circle material in class VIII. The following are the results obtained at each stage of the research.

a) Analysis

The content of the developed application is mathematics on Circle material for class VIII. Characteristics of the material The circle contains a description of the material in the form of text, images, scientific symbols, and mathematical formulas. Multimedia is developed by applying the drill and practice method. The drill and practice method in learning media has a flow that starts with giving a description of the material to students then given practice questions to be answered by students with correct or incorrect information in response to the answers entered by students so that they can immediately know whether their answers are right or wrong. Evaluation of the results of the analysis suggested the use of GeoGebra to support the discussion on the sub-material of the relationship between the center angle and the circumference angle. So the technology needed for development can be seen in Table 5.

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No	Needs	Technology
1	Organize or create content for learning media	HTML
2	Set the display layout on the learning media	CSS
3	Respond to user input or user interaction	JavaScript
4	Store data such as practice questions, answers, and user grade results	Firebase Realtime Database, JSON
5	Creating images and displaying graphs related to circle material	Geogebra
6	Creating interactive animations on learning media	Scratch
7	Displaying mathematical symbols contained in the circle material	MathJax
8	Hosting learning media so that they can be accessed via the internet	Netlify

Table 5: Technology used

b) Design

At this stage, the design of the presentation of teaching material content, the design of use case diagrams, the design of the site map, the design of features and the design of the database are generated. Feature design created using Balsamiq Mockups. Figure 1 shows an example of a feature design for a content page. The material page is designed to have two columns, namely the navigation column and the material exposure column.

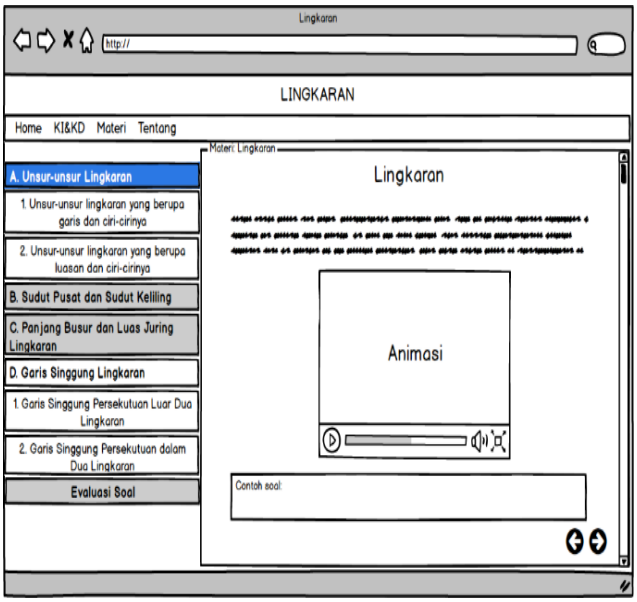

Fig. 1: Example of Interactive Multimedia Interface Design

The design results were evaluated by the research team. After further improvements, the material design was validated by two material experts from ULM Mathematics Education. Table 6 shows the results of material validation.

Aspek	NI	Score		RC	Criteria
		Validator 1	Validator 2		
Content Eligibility	8	23	28	3.19	high
Serving Eligibility	10	28	34	3.10	high
Language Eligibility	8	26	28	3.38	high
Total	26	77	90	3.21	high

Table 6: Material expert validation results

Ket: NI = Total item; RC= average performance

The design of teaching materials is improved according to the comments and suggestions that have been submitted by the validator. From Table 6 it can be seen that the validity of the material obtained an average achievement of 3.21, which is included in the high criteria. This means that the material design is declared valid, so that teaching materials can be used as content from the developed interactive multimedia.

c) Development

This stage is an activity to create interactive learning media using technology that has been determined at the analyst stage. Figure 2 shows the main page, which was developed using HTML and CSS technology.

Fig. 2: Main page view

The main page contains three menus, namely the About menu, KI-KD menu, and the Material menu. The About page contains information about the application, a reference list, and instructions for use. The KI-KD page contains an explanation of the core competencies and basic competencies of circle material in class VIII. The material page contains a description of the circle material consisting of a menu navbar in the left column which contains a list of sub-topics and sub-subjects of discussion. In the right column contains a description of the material consisting of the title of the sub-topic material to be delivered, the learning objectives, the title of the sub-sub-topic material, there is also a next button at the bottom that directs the user to the next page or the previous page. To help users understand the material, some presentations of the material are also accompanied by corresponding images. In the

description of the material there is an explanation of the material that is made interactive, as can be seen in Figure 3.

Fig. 3: An example of an interactivity display on a content page

To test the user's understanding at the end of each sub-chapter there is a quiz. While at the end of the material there is an evaluation. The questions contained in the quiz or evaluation are in the form of multiple choice. The quiz or evaluation page is divided into two columns. The left column displays the text of the question and its answer choices, as well as a button to move from one question to another. The right column displays a list of question numbers that can also be used as navigation to move to the desired question number. The questions presented on the quiz or evaluation page are displayed randomly, so that each time the user is accessed, they will get a different order of questions. Figure 4 shows an example of a quiz page view. The finish button under the question number list column is used to submit answers.

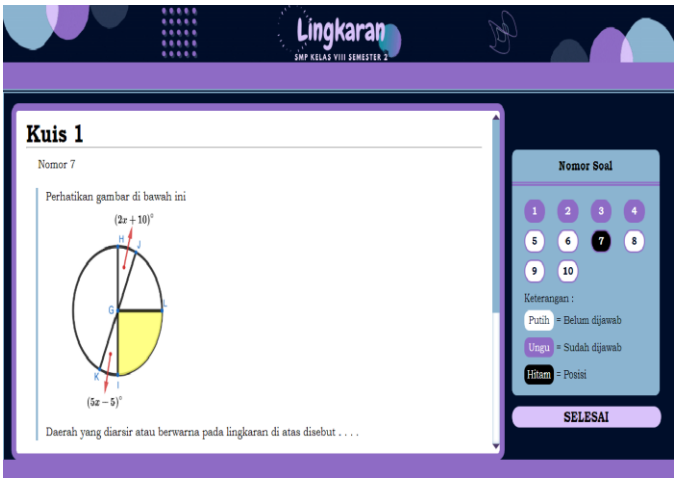

Fig. 4: Sample quiz page display

Quiz or evaluation results can be displayed on the teacher page. This page is only accessible to teachers. The display of the grade list page can be seen in Figure 5. Teachers can display a list of student grades by selecting the school and class they want to display. If needed, the teacher can download the list of grades in excel format.

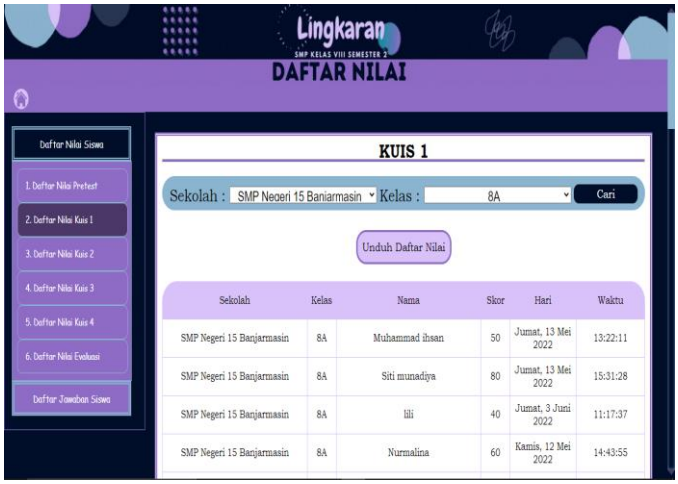

Fig. 5: Display of the list of grades on the teacher's page

The results of the subsequent development were validated by two media experts from ULM Computer Education. Table 7 shows the results of media validation by two experts

Aspect	NI	Score		RC	Criteria
		Validator 1	Validator 2		
Feedback and Adaptation	1	4	3	3.50	high
Presentation Design	7	24	22	3.29	high
Interaction Usability	3	10	10	3.33	high
Total	**11**	**38**	**35**	**3.32**	**high**

Table 7: Media expert validation results

Ket: NI = Total item; RC= average performance

After being corrected according to the suggestions, the validator stated that the interactive multimedia circle developed was declared valid in terms of media. It can be seen in Table 7, that the average achievement for media validity is 3.32, with high validity criteria. The multimedia developed was declared valid by material experts and media experts with high criteria. This means that multimedia is declared valid, and can be used for trials in learning.

d) Implementation

The implementation stage is carried out when the developed multimedia has been declared valid based on the material and media validity test by material and media experts. At this stage the developed multimedia is used in classroom learning. This learning media trial was conducted face-to-face, in class VIII A of State Junior High School 15 Banjarmasin which was attended by 15 students. The trial was carried out in May 2022. The trial began with a pretest of mathematical problem solving ability and ended with a posttest of mathematical problem solving ability. The average pretest and post-test results of mathematical problem solving abilities can be seen in Table 8

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Activity	Average	Criteria
Pretest	3.69	Very low
Posttest	75.00	Good

Table 8: Average results of pretest and post-test

Table 8 shows the problem-solving abilities of students, after learning with the help of interactive multimedia is in good qualification. Furthermore, based on the pretest and posttest scores, the average N-gain value was calculated. The average N-gain value is 0.7670 with high qualifications. Based on these results, the interactive multimedia developed can be declared effective.

After the posttest, students fill out the user response instrument. Many respondents are 15 students and one teacher. The responses of students and teachers to the use of interactive multimedia in circular learning can be seen in Table 9.

No	Aspect	Learners		Teacher	
		Total Items	Score	Total Items	Score
1	Ease of use and navigation	2	104	2	8
2	Cognition Content	3	151	2	7
3	Scope of Knowledge and Presentation of Information	3	145	2	7
4	Aesthetics	2	102	2	6
5	Overall Functions	1	52	2	7
6	Ease of Learning	4	202	2	7
Amount		15	15	12	42
Average Achievement		**3.36**		**3.5**	

Table 9: User response results

The average student response achievement in Table 9 shows a value of 3.36, based on Table 1 it is in the positive criteria. While the teacher's response reached an average of 3.5 with positive criteria. All user responses are positive, thus the multimedia developed can be said to be practical.

B. Discussion

Based on the results of the analysis, it is shown that interactive multimedia developed as a support for mathematical problem-based learning in junior high schools is a valid, practical and effective learning media. Thus, this media can be used as a solution in learning mathematics that is interesting, not static and innovative. This is in accordance with the opinion (Tatang, 2018) who states that the advantages of web-based mathematics learning media are 1) the display of the media is simple but elegant, 2) it contains video tutorial content 3) the material is described in sequence so that students are easier to understand, adding supplements student learning.

The results of the validation of the materials and media developed were respectively in the high criteria with an average of 3.21 and 3.32. This shows that the material and media are feasible to be used for field trials. Based on the average value of the pretest and post-test, the media developed was asked to be effective, because it could improve the test results which initially had an average of 3.69 to 75.00.

Based on the practicality test, the developed media can be declared practical because it gets a positive response from students.

IV. CONCLUSION

Interactive multimedia on circle material for class VIII has been successfully developed, using several technologies, namely, HTML, CSS, JavaScript, JSON, Firebase, Scratch, GeoGebra, MathJax, and Netlify. Based on the results of the feasibility test, this product is declared valid in terms of material and media with high validity criteria. Based on the students' mathematical problem solving ability, the product is declared effective. Based on user responses, the developed multimedia is stated to be practical. Thus the interactive multimedia in this circle material is suitable for use in class VIII.

V. RECOMMENDATIONS

This study identifies two implications for further research. First, examine practical and appropriate strategies to improve students' completion abilities, especially in the early years of junior high school. Second, increasing the number of students in the research object.

LIMITATIONS

This study has investigated how students' mathematical problem solving abilities correlate with the interactive multimedia used. However, this study has a limited study area which causes a lack of representativeness of the sample. This research must also be combined with qualitative methods to obtain more comprehensive data.

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